

## NEW PATENT APPLICATION

## CHECKLIST FOR MATTERS OF FORM

Examiner:

The items checked below have been noted in processing this application as filed. After the typist has included these statements in the first Office action, please initial the appropriate paragraph. Please do NOT remove from the file jacket.

## 1. SPECIFICATION, JUMBO APPLICATION NOT CHECKED FOR MINOR ERRORS (If more of claims.)

- ☐ Because of the lengthy specification in this application, it has not been checked for the presence of all possible minor errors. Applicant's cooperation is therefore required errors of which he may become aware in the specification or drawings.

## 2. RESIDENCE OMITTED (MPEP 605.02 and 603.03)

- ☐ Applicant's residence has been omitted from the papers. The city and state of his residence to be the city and state of his residence. If the above is incorrect, applicant should residence no later than at the time of payment of the issue fee.

## 3. PRIORITY PAPERS, ACKNOWLEDGMENT (MPEP 201.14(c))

- ☐ Receipt is acknowledged of papers submitted under 35 U.S.C. 119, which papers have

## 4. PRIORITY PAPERS, ACKNOWLEDGMENT, PAPERS IN PARENT APPLICATION (MPEP 201.14(c))

- ☐ Applicant's claim for priority, based on papers filed in parent application Serial No. \_\_\_\_\_ under 35 U.S.C. 119, is acknowledged.

## 5. PRIORITY, CLAIM FOR BUT NO PAPERS FILED (MPEP 201.14(c))

- ☐ Acknowledgment is made of applicant's claim for priority based on an application filed on 7-19-60. It is noted, however, that applicant has not filed a certified copy of the application required by 35 U.S.C. 119. *Kingdon*

## 6. PRIORITY PAPERS, MORE THAN ONE YEAR SINCE FILING IN FOREIGN COUNTRY (MPEP 201.14(c))

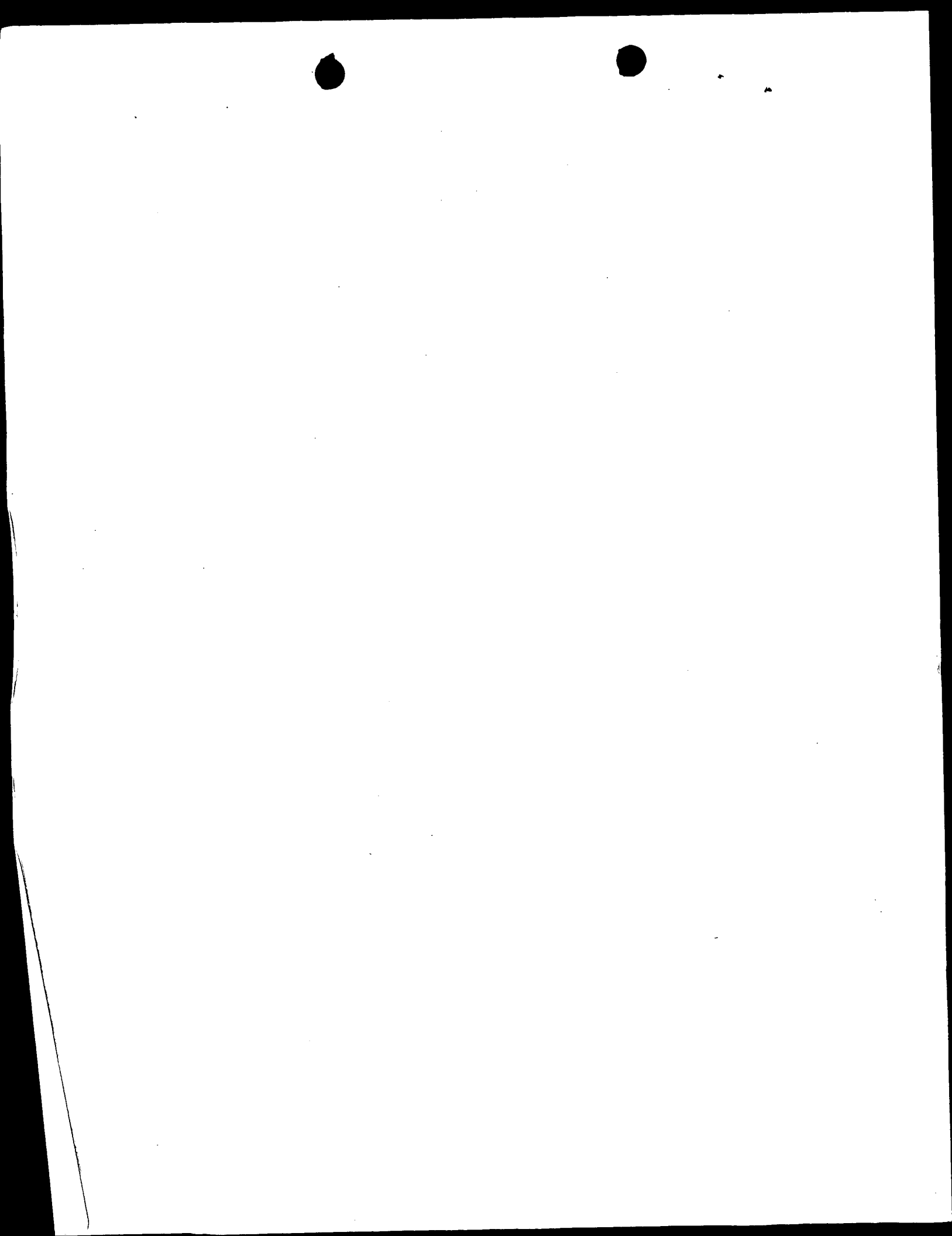
- ☐ Receipt is acknowledged of the filing on \_\_\_\_\_ of a certified copy of the application referred to in the \_\_\_\_\_ of a claim for priority. Since the United States application was filed more than twelve months thereafter, a claim for priority is not allowed.

## 7. PRIORITY, REFERENCE IN OATH OR DECLARATION OMITTED (MPEP 201.14(c))

- ☐ Receipt is acknowledged of papers filed \_\_\_\_\_ based on an application filed on \_\_\_\_\_ since the \_\_\_\_\_ Applicant has not complied with the requirement that the applicant does not acknowledge the filing of an application in a foreign country. \_\_\_\_\_ is required.

\* INSERT EITHER "DECLARATION" OR "OATH", WHICHEVER IS APPLICABLE.

*Sticker**5-18-60*





INVESTOR IN PEOPLE

Poramaste Jinupun  
18 Tomsfield Road  
HATFIELD  
Hertfordshire  
AL10 9TB

**The Patent Office  
Patents Directorate**

Concept House  
Cardiff Road, Newport  
South Wales NP10 8QQ  
United Kingdom

J1046 U.S. PTO  
09/804792



Direct line: 01633 814965  
†E-mail: martin.leighton@patent.gov.uk  
Switchboard: 01633 814000  
Minicom: 08459 222250  
Fax: 01633 814444  
DX 722540/41 Cleppa Park 3  
<http://www.patent.gov.uk>

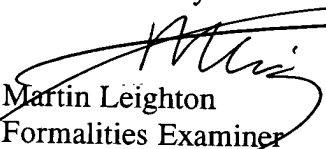
Your reference: -  
Application number: GB 0022600.1

6 March 2001

*#2  
Priority  
Cthick  
5-18-01*

*With Compliments*

Yours sincerely

  
Martin Leighton  
Formalities Examiner

---

†Use of E-mail: Please note that e-mail should be used for correspondence only.





INVESTOR IN PEOPLE

The Patent Office  
Concept House  
Cardiff Road  
Newport  
South Wales  
NP10 8QQ

*#2  
Priority  
C. Hebbon  
5-18-01*



I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

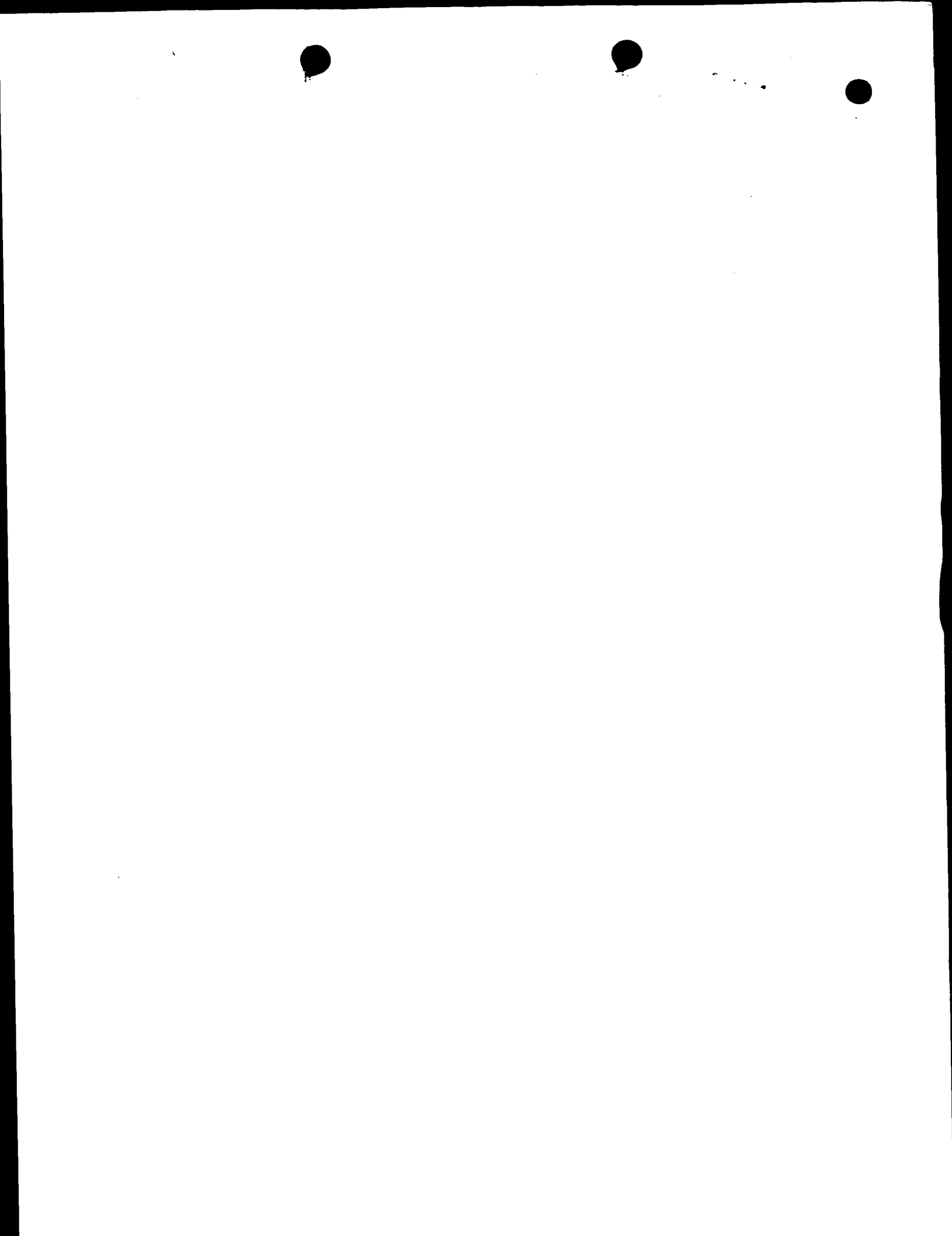
In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

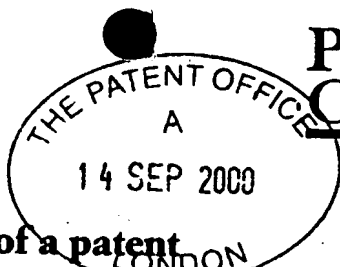
Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed

Dated

6 March 2001





15SEP00 E568440-1 C66280  
P01/7700 0.00-0022600.1

# Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road  
Newport  
Gwent NP9 1RH

22 AUG 2000

1. Your reference

PORAMASTE JINUPUN

2. Patent application number

(The Patent Office will fill in this part)

0022600.1

3. Full name, address and postcode of the or of each applicant (underline all surnames)

PORAMASTE JINUPUN

18 TOMSFIELD RD.

HATFIELD. 7397474003

HERTFORDSHIRE AL10 9TB

Patents ADP number (if you know it)

If the applicant is a corporate body, give the country/state of its incorporation

4. Title of the invention

MULTI-CIRCULAR FLUX MOTOR

5. Name of your agent (if you have one)

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

Patents ADP number (if you know it)

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

Country

Priority application number  
(if you know it)

Date of filing  
(day / month / year)

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing  
(day / month / year)

0020681.3

22 AUG 2000

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:

a) any applicant named in part 3 is not an inventor, or

b) there is an inventor who is not named as an applicant, or

c) any named applicant is a corporate body.

See note (d))

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form

Description	12 PAGES
Claim(s)	7 PAGES
Abstract	1 PAGES
Drawing(s)	23 PAGES + 23

10. If you are also filing any of the following, state how many against each item.

Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (Patents Form 7/77)

Request for preliminary examination and search (Patents Form 9/77)

1

Request for substantive examination (Patents Form 10/77)

1

Any other documents (please specify)

11.

*Pramato Jimpun*

I/We request the grant of a patent on the basis of this application.

Signature

*14/9/2000*

Date

12. Name and daytime telephone number of person to contact in the United Kingdom

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

- If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.
- Write your answers in capital letters using black ink or you may type them.
- If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.
- If you have answered 'Yes' Patents Form 7/77 will need to be filed.
- Once you have filled in the form you must remember to sign and date it.
- For details of the fee and ways to pay please contact the Patent Office.



## MULTI-CIRCULAR FLUX MOTOR

### FIELD OF THE INVENTION

The invention related to a reluctance motor with a silent pole rotor and stator having winding on either a rotor pole or a stator pole. The invention is a new type of machine in its class because it uses the new technique, multi-circular flux loops (a series of flux loop or a series of circular flux loops), to produce reluctance torque. The invention can implement in alternating current (AC) and direct current (DC) pulse. The invention can apply with a simultaneous phase excitation without flux cancellation between phases. The invention has no a permanent magnet on both a rotor pole and a stator pole, has a simple salient pole and has no physical commutation but commutates by means of electronically commutation.

### BACKGROUND OF INVENTION

The invention is built up by using the principle of reluctance torque. This invention can be named 'a multi-circular flux motor' the background of the technique came from a short flux loop of a reluctance machine especially a switched reluctance motor. By mean of the short flux loop the electromagnetic flux can be an individual from other flux loops or other phases and a core loss of the machine reduces. As an individual electromagnetic flux loop the motor can be constructed as a servo-machine. However, the short flux loop machine such as a 12/10 pole switched reluctance motor (see invention US 4,883,999) has limitation of designs. The motor cannot have a low number of poles, therefore the motor has to use with a very high frequency to achieve a high speed (the 12/10 switched reluctance motor use 60 Hz to achieve 360 rpm while a 2-pole induction motor use 60 Hz to achieve 3600 rpm). Switched reluctance motor structures are difficult to apply in an AC machine unlike synchronous reluctance motors that can apply in AC machine except just they have a complex rotor which difficult to build. The benefits over having an AC machine application are:

- Using only two current sensors measure 3-phase current.
- The machine runs twice times faster than using the DC pulse, for example 50 Hz AC machine run at actual 100 Hz compare to the DC pulse machine such as a switched reluctance motor, because the AC machine is a bipolar current machine while a DC pulse machine is a unipolar current machine.
- Using a sinusoidal signal gets a low harmonic.

The principle of this invention can be applied in a linear motor, a rotating machine and a moving part machine. From the prior art shown in Fig.1, a switched reluctance motor tooth shows flux density on both a stator and rotor tooth, the flux density thereby aligned teeth is very condensed than other area and having uneven of saturation level. Conventional switched reluctance motors are usually work by a long flux loop with a fully aligned and fully unaligned condition of their big tooth makes very hard to configure the motor structure. For example a 6/4 pole 3-phase cannot driven by a simultaneous 3-phase excitation and is not appropriate to use an alternating current with their structure. Although some of a switched reluctance motors work by a short flux loop and might be possible to drive by a simultaneous 3-phase excitation but its configuration makes the machine have many teeth. For example, the 12/10 poles 3-phase (see invention US 4,883,999) and a characteristic of the motor type are a highly non-linear, therefore the potential of high-speed application is limited by core loss, switching loss and low inductance ratio making a low torque output and very difficult to control by the problem of a non-linear characteristic of the motor.

## SUMMARY OF THE INVENTION

The invention has shared a theory to prior art in a term of reluctance torque between teeth except a winding pole of the invention has been subdivided into plural teeth and work together by a group of short flux loops. A short flux loop that use in a switched reluctance machine, its stroke angle or step distance depends on a tooth width. The way of the invention a winding tooth width can be small as need without an effect to its stroke angle or step distance. The resolution of rotation or linear movement does not depend on the winding tooth width but depends on the winding pole width. This very importance feature makes the invention unique from a conventional short flux loop in a switched reluctance machine. Subdivided teeth with windings of the invention together perform the function as one big winding pole. The invention is not an alignment of teeth but is an alignment of poles, using individual flux loop of those subdivided teeth makes an isolation of each pole and each phase independently therefore the invention can be constructed to be a new type of a machine. By means of using a subdivided tooth, a pole space between phases can be reduced as the tooth space, the invention have a high inductance ratio and the rotor core can use a lightweight material to make a low inertia rotor therefore the invention can be designed to a new type of a machine by its own ways.

### The invention principle can be described by the following:

The invention comprised of a salient pole rotor and a salient pole stator. The rotor pole width is about the stator pole width. Each stator pole (a winding pole) is subdivided into plural stator teeth. All windings of the plural stator teeth of each stator pole are connected together to be one phase winding. The phase winding of each stator pole is excited to perform electromagnetic poles. All odd stator teeth of each stator pole are either North poles or South poles. All even stator teeth of each stator pole are either North poles or South poles. The electromagnetic poles of the odd stator teeth and the even stator teeth are opposite. Each stator tooth generates linking flux loops to both adjacent teeth to complete its electromagnetic flux loops. The both adjacent teeth are a right-hand adjacent tooth and a left-hand adjacent tooth. The electromagnetic flux loops of the stator tooth consist of a left-hand linking flux loop and a right-hand linking flux loop. The left-hand linking flux loop is either a left or right rotation direction. The right-hand linking flux loop is either a left or right rotation direction. The left-hand linking flux loop of the odd stator teeth and the right-hand linking flux loop of the even stator teeth are the same rotation direction. The right-hand linking flux loop of the odd teeth and the left-hand linking flux of the even teeth are the same rotation direction. The linking flux loops are joined together as a series of flux loops or a series of circular flux loops (multi-circular flux loops). The flux loop where a rotor pole-corner is aligned with the stator pole produces reluctance torque to rotate or move the rotor pole, then the next flux loop where the rotor pole-corner is increasingly aligned with the stator pole produces reluctance torque to continue rotate or move until the rotor pole is fully aligned with the stator pole. A stroke angle or a step distance does depend on the stator pole width but does not depend on the small stator teeth.

\*Note: the circular flux loop is, [the flux loop] or [the left-hand linking flux loop of odd tooth + the right-hand linking flux loop of even tooth] while the multi-circular flux loops are a series of circular flux loops or a series of flux loops.

The invention using a method of the multi-circular flux loops to produce reluctance torque can be explained in simple drawings shown in Fig.2, Fig.3 and Fig.4

The operation of the simple invention shown in Fig.2 comprised with the non-permanent magnet rotor pole (1a), the non-permanent magnet stator pole (1b), subdivided teeth (2) with windings (5), tooth spaces (4) and stator pole-ends (3, 10). *Every tooth of the stator pole is wound, wound inversely to each other adjacent and all are connected together in either a series or a parallel to be one phase winding.* The windings are excited to generate the circular flux loop (6) inversely rotation direction to each other adjacent. The most effective circular flux loop (8) produces reluctance torque to complete its electromagnetic flux loop, then the next circular flux loop (9) becomes the most effective circular flux loop and repeats the same operation to make rotor pole move to direction (7) until the end of the stator pole (10) the rotor pole (1a) stops movement. The rotor pole width is about a stator pole width from the pole-end (3) to (10) and can be extended about a half of tooth width of the stator pole to make a smooth movement between poles (in poly-phase case).

The operation of the simple invention shown in Fig.3 comprised with the non-permanent magnet rotor pole (11a), the non-permanent magnet stator pole (11b), subdivided teeth (12) with windings (15), tooth spaces (14) and stator pole-ends (20, 13). *Every odd tooth of the stator pole is wound, wound in the same direction and all are connected together in either a series or a parallel to be one phase winding.* The windings are excited to generate a circular flux loop (16) inversely rotation direction to each other adjacent. The most effective circular flux loop (18) produces reluctance torque to complete its electromagnetic flux loop, then the next circular flux loop (19) becomes the most effective circular flux loop and repeats the same operation to make a rotor pole move to direction (17) until the end of stator pole (20) the rotor pole (11a) stops movement. The rotor pole width is about a stator pole width from pole-end (13) to (20) and can be extended about a half of tooth width of a stator pole to make a smooth movement between poles (in poly-phase case).

The operation of the simple invention shown in Fig.4, comprised with the non-permanent magnet rotor pole (21a), the non-permanent magnet stator pole (21b), subdivided teeth (22) and windings (25), tooth spaces (24) and stator pole-ends (23, 30). *Every even tooth of the stator pole is wound, wound in the same direction and all are connected together in either a series or a parallel to be one phase winding.* The windings are excited to generate a circular flux loop (26) inversely rotation direction to each other adjacent. The most effective circular flux loop (28) produces reluctance torque to complete its electromagnetic flux loop, then the next circular flux loop (29) becomes the most effective circular flux loop and repeats the same operation to make a rotor pole move to direction (27) until the end of a stator pole (30) the rotor pole (21a) stops movement. The rotor pole width is about a stator pole width from a pole-end (23) to (30) and can be extended about a half of tooth width of a stator pole to make a smooth movement between poles (in poly-phase case).

The connection of the windings of the winding pole can be either a parallel or series and depends on particular design.

*The series connection*, an inductance and a flux-linkage profile is increasing by linear make ease of finding rotor position. The series connection not only good for ease of finding rotor position but also good for having a constant torque by a constant current control through the series of windings. The disadvantage of the series connection is using a high voltage source.

*The parallel connection*, an inductance and a flux-linkage profile also are increasing by linear but it has a low scale changing make difficult of finding rotor position. This connection suits for a high inductance application that use lower voltage source than the series connection however in a normal circumstance, the series connection is more suitable than parallel connection.

Finding rotor position of the invention is not difficult even in saturation mode because all aligned teeth have similar level of saturation while the remained unaligned teeth have a higher inductance ratio than all aligned teeth.

The invention has lower torque ripple than a conventional reluctance machine by the ways of a continuing torque of plural teeth (31) of one phase as shown in Fig.5 therefore the machine rotates or moves smoothly (32) and is suitable for servo controls. Unlike a conventional switched reluctance motor teeth is too wide a characteristic of torque is vary by position, as a result every alignment position has its own characteristic (33), which is non-linear.

The ways of having inverse flux rotation direction to each other adjacent can be done in two ways, first way every tooth of stator pole is wound inversely direction to each other adjacent and second way every tooth is wound in the same direction and every winding terminal is inverted polarity to each other adjacent.

Increasing the rotor pole width about a half of tooth width of the stator pole makes a smooth rotation or movement between poles by the mutual flux (34 and 35 in Fig.6a and Fig.6b, respectively) and by overlapping the phase excitation between two phases produces a low torque ripple.

The invention has no required a large pole space for the winding pole therefore the way of motor or machine design by the invention technique is different from a switch reluctance motor. A switched reluctance motor requires a large pole space for the winding pole to make unaligned condition while the invention needs just only a subdivided tooth space to make unaligned condition therefore the adjacent winding pole of other phases can place next to with a subdivided tooth space in between.

The invention perform a poly-phase machine by using plural poles and plural phases:

**A non-overlap-pole type as DC pulse machine**, a number of stator teeth per stator pole can be odd or even number but they use in different way of design to configure the motor winding. In case of an odd number of teeth per pole the multi-circular flux loops direction at the both ends of a winding pole are different rotation direction therefore to combine phases between winding poles every winding pole have to invert the phase winding to each other adjacent to eliminate flux cancellation between winding poles (see Fig.6a). In case of an even number of teeth per pole the multi-circular flux loops direction at the both ends of the winding pole are the same rotation direction therefore to combine phases between winding poles no need to invert the phase winding (see Fig.6b). The odd number of teeth per stator pole, every winding pole has to invert the phase winding to each other adjacent as Fig.6a, phase (-a), phase (+B) and phase (-C), respectively. The even number of teeth per stator pole of this winding type does not have to invert the phase winding as Fig.6b, phase (A), phase (B) and phase (C) for examples in linear motor (Fig.11c) and in rotating machine (Fig.12, Fig.13 and Fig.14). The motor can be driven by a 3-phase DC pulse source (Fig.23a).

The best mode of the invention (Fig.7a and Fig.7b), the overlap of the phase winding (38, 39) is  $1/3$  in 3-phase motor ( $1/4$  in 4 phase and  $1/5$  in 5-phase motor).

**An overlap-pole type as DC pulse machine** (Fig.7a) is a winding for a DC pulse motor, having a smooth transition between poles by means of mutual flux between phases with  $1/3$  overlap winding pole in 3-phase machine. A number of stator teeth in this winding type can be an odd or even number with no limitation of configurations of a number of rotor poles, the invention by this winding can be any number of poles such as 2 poles, 3 poles, 4 poles, 5 poles and 6 poles shown in Fig.15, Fig.16, Fig.17, Fig.18 and Fig.19, respectively. The motor can be driven by the 3-phase DC pulse source (Fig.23b). Increasing a rotor pole width about a half of tooth width of a stator pole to make a smooth rotation of movement between poles by a mutual flux (36 and 37 in Fig.7a and Fig.7b) and by overlap excitation between phases produces a low torque ripple.

*An overlap-pole type as AC machine* (Fig.7b) the circular flux loop rotation direction depends on a polarity of AC source therefore no flux rotation direction are shown in Fig.7b. The winding for an AC motor, having a smooth transition between poles and by means of mutual flux between phases with 1/3 overlap winding pole in 3-phase machine. A number of stator teeth in this winding type can be only an even number and the invention by this winding can be an even number of poles such as 2 poles, 4 poles and 6 poles shown in Fig.20, Fig.21 and Fig.22, respectively. The invention in this winding type for AC motor every winding pole has to either inversely wound windings or invert the phase winding terminal to each other adjacent to eliminate flux cancellation.

By using RIGHT-HAND-RULE, the circular flux loop rotation direction can be identified to a right rotation or a left rotation direction. In Fig.9a is simply by wound overlapping with the same current polarity, in Fig.9b, every winding pole has to invert the phase winding to each other adjacent to eliminate flux cancellation while using alternating current mode (AC machine). At a time that 2 phases of 3-phase voltage have a same polarity (see Fig.23,  $(-V_c, -V_b, +V_a)$ ,  $(-V_c, +V_b, -V_a)$ ,  $(-V_c, +V_b, +V_a)$ ,  $(+V_c, -V_b, -V_a)$ ,  $(+V_c, -V_b, +V_a)$ ,  $(+V_c, +V_b, -V_a)$ ,  $(+V_c, +V_b, +V_a)$ ) therefore an AC machine every winding pole has to invert the phase winding to each other adjacent in accordance with the alternating current (see examples of invention of AC machine shown in Fig.20, Fig.21 and Fig.22). The phase winding of the machine can be connected together as a star or delta topology and can be driven by a 3-phase AC source (Fig.23c).

The invention shown in Fig.2 explains in term of a current direction of the winding related to the multi-circular flux loops rotation direction shown in Fig.8a and Fig.8b. All windings are connected together in either a series or parallel to be one phase winding. Every winding in each slot is driven by current inversely direction to each other adjacent. The Fig.8b is used in some special circumstance such as a need of very small tooth. The invention can work without a tooth on a winding pole but the rotor pole have to be very close to a toothless-stator and the winding space is still necessary to perform as an invisible tooth. An operation of the invention shown in Fig.8a and Fig.8b can be explained in the same way as the invention shown in Fig.2 of the previous part. The 3-phase winding in Fig.7a and 7b explain in term of a current direction of the winding related to the multi-circular flux loops rotation direction as show in Fig.9a and Fig.9b, respectively.

## THE INVENTION DETAILED DESCRIPTION

From the simple invention, it can apply in several type of invention such as the linear motor or actuator in Fig.10. The invention comprised with the stator part (40), the rotor part (41), the windings (42) and rotor support (43). The windings generate multi-circular flux loops (44) and the most effective circular flux loop (46) produces reluctance torque make the rotor or actuator move to direction (45).

To control the movement direction of the invention, at least has to be a 3-phase machine. The simple invention shown in Fig.10 can be configured to a 3-phase linear motor as shown in Fig.11a and Fig.11b. The linear motor shown in Fig.11a, having an overlapping and interaction between phases through the rotor body (48) by ratio of  $1/3$  of the rotor width in the 3-phase machine. For different configuration such as a 4-phase, 5-phase and 6-phase an overlapping are  $1/4$ ,  $1/5$  and  $1/6$ , respectively. The linear motor can use with DC pulse and AC source in the same structure because all winding poles are separated therefore the pole phase excitation can be either +A or -A (47a), +B or -B (47b) and +C or -C (47c). In case of rotating machine to have this capability, the motor has to be a multi-stack motor. Using the overlap-pole type of linear motor, the winding should be located on rail or track. By having winding on the rotor makes the linear motor unbalance of the mutual flux at the both ends of a motor however, it is also possible to do. Using the invention structure shown in Fig.12 to Fig.22 by changing structure from rotating to linear movement therefore the invention can apply so widely from a motion control to transportation or traction. In case of the need of simple structure of rail or track therefore the invention shown in Fig.11a is the most suitable for the rotor winding type.

Alternative of invention of linear motor shown in Fig.11b and Fig.11c, also a 3-phase linear motor except the motor has no overlapping between the rotor bodies. The invention can be built in two structure choices. *The first choice* (Fig.11b) is an old design as the motor shown in Fig.11d each stator pole can place far from each other about one pole space the pole phase excitation can be either +A or -A (50a), +B or -B (50b) and +C or -C (50c) however, the disadvantage of this configuration is the stator is a long length. *The second choice* (Fig.11c) has mutual flux while changing pole to pole that makes the invention move smoother than the first choice. The benefit of the invention shown in Fig.11b and Fig.11c has over the invention shown in Fig.11a when no winding on a rail or track and windings on rotor, uses less stator lamination than the rail or track of the invention show in Fig.11a, which is the way to make a cheaper rail or track for transportation. In case of a number of teeth per pole at the winding pole is odd number, therefore every winding pole has to invert the phase winding to each other adjacent, for example, +A, -B, and +C (in case of 2-pole rotor therefore phase windings are +A, -B, +C, -A, +B and -C). In case of a number of teeth of the winding pole is even number it no needs to invert the phase winding of invention.

In fact, the invention can configure such as a  $6/4$  pole 3-phase rotating motor,  $8/6$  pole 4-phase motor,  $10/8$  pole 5-phase motor, and  $14/12$  pole 7-phase motor like a switched reluctance motor by replacing every one pole of each phase with an invention of one pole of Fig.2, Fig.3, Fig.4, Fig.8a or Fig.8b. For example, a 3-phase motor with 4 pole rotor, a similar function to a  $6/4$  pole switched reluctance machine as shown in Fig.11d, the rotor is rotated by the new method of the invention. In this motor all winding poles are separated by using a series of flux loops of the invention to produce reluctance torque therefore the pole phase excitation can be either (+A) or (-A) in phase A, (+B) or (-B) in phase B, and (+C) or (-C) in phase C. Because an individual of each winding pole, the rotor core can applies a lightweight material or hollows to make low rotor inertia. A number of teeth on winding pole can increases without decreasing a stroke angle therefore making a low torque ripple.

However to get high efficiency of the motor needs to use the new design strategies. By a new design of the invention can apply to an unusual configuration such as a 3 pole 3-phase motor with non-overlap-pole type (Fig.13), a 3-pole 3-phase motor with overlap-pole type (Fig.16) and a 5-pole 3-phase motor with overlap-pole type (Fig.18) with balancing torque structure makes it unique from a switched reluctance motor. A switch reluctance motor needs a large pole space for a winding pole to make unaligned condition with this invention need just only a subdivided tooth space to make unaligned condition therefore the adjacent winding pole of other phases can place next to with a subdivided tooth space in between. Therefore, the ways of motor design of the invention are different from a switched reluctance. Comparison to a conventional switched reluctance motor, for example in 6/4 poles 3-phase motor stroke angle is  $30^\circ$  while the invention configures a 4 poles 3-phase with non-overlap-pole type as shown in Fig.14 its stroke angle is  $30^\circ$  and get a strong flux because it works with 4 poles at a time. The invention even better than the conventional switched reluctance in term of stroke angle when the overlap-pole is employed for example a 4-pole 3-phase with overlap-pole type as shown in Fig.17 for DC PULSE and Fig.21 for AC their stroke angle are  $45^\circ$ .

### *The basic design of invention*

#### The non-overlap-pole type as DC pulse machine

The invention by this configuration can be any odd or even number of rotor poles (for examples see Fig.12, Fig.13 and Fig.14, they are 2 poles, 3 poles and 4 poles, respectively). However an indication of odd or even type is that, in case of the number of stator teeth per pole is even number the invention configuration can be even or odd number of rotor poles. In case of the number of stator teeth per pole is odd number the invention configuration can only be an even number of rotor poles and every winding pole has to invert the phase winding to each other adjacent. For example phase windings in 3-phase 2-pole are +A, -B, +C, -A, +B and -C, respectively. To design a motor can be done by following steps.

1. Declare a number of rotor poles.
2. Declare a number of phases.
3. A total number of stator poles = [a number of rotor poles] \* [a number of phases].
4. Declare a number of stator teeth per pole.
5. A total number of stator teeth = [A total number of stator poles] \* [a number of stator teeth per pole]
6. Minimum teeth per pole for a 3-phase non-overlap-pole type are two teeth to generate a one short flux loop between teeth and two short flux loops at both ends of the multi-circular flux loops. To get a benefit over the invention of a low torque ripple should declare a high number of stator teeth per pole with optimising a practical winding.
7. A stroke angle of the invention =  $360 / \text{a number of poles}$ .
8. A number of windings depend on a selected way of an invention winding (Fig.2, Fig.3 and Fig.4) and a number of stator teeth per pole.

As shown in Fig.12 the motor is 2-pole rotor, 3 phases and a number of stator teeth per pole are 10 teeth as a result:

A total number of stator poles =  $2 * 3 = 6$  poles.

A total number of stator teeth =  $6 * 10 = 60$  teeth.

A stroke angle =  $360 / 6 = 60^\circ$ .

If selected way of invention windings is the same as Fig.2 therefore a number of windings = 10 teeth per pole (a total number of windings =  $6 * 10 = 60$  windings).

As shown in Fig.13 the motor is 3-pole rotor, 3 phases and a number of stator teeth per pole are 6 teeth as a result:

A total number of stator poles =  $3 * 3 = 9$  poles.

A total number of stator teeth =  $9 * 6 = 54$  teeth.

A stroke angle =  $360 / 9 = 40^\circ$ .

If selected way of invention windings is the same as Fig.2 therefore a number of windings = 6 teeth per pole (a total number of windings =  $9 * 6 = 54$  windings).

Example of the invention, shown in Fig.14 the motor is 4-pole rotor, 3 phases and a number of stator teeth per pole are 5 teeth as a result:

A total number of pole =  $4 * 3 = 12$  poles.

A total number of stator teeth =  $12 * 5 = 60$  teeth.

A stroke angle =  $360 / 12 = 30^\circ$ .

If selected way of invention windings is the same as Fig.2 therefore a number of windings = 5 teeth per pole (a total number of windings =  $12 * 5 = 60$  windings).

The invention has varieties of configurations. The examples of configurations that the invention can be applied are:

- A 5-pole 3-phase motor with stroke angle  $24^\circ$ ,
- A 6-pole 3-phase motor with stroke angle  $20^\circ$ ,
- A 7-pole 3-phase motor with stroke angle  $17.143^\circ$ ,
- A 8-pole 3-phase with stroke angle  $15^\circ$ ,
- A 9-pole 3-phase motor with stroke angle  $13.33^\circ$ ,
- A 10-pole 3-phase motor with stroke angle  $12^\circ$ ,
- A 11-pole 3-phase motor with stroke angle  $10.09^\circ$ ,
- A 12-pole 3-phase with stroke angle  $10^\circ$ ,
- Etc.

#### The overlap-pole type as DC pulse machine

The invention by this configuration can be either odd or even number of rotor poles (for examples see Fig.15, Fig.16, Fig.17, Fig.18 and Fig.19, they are 2 poles, 3 poles, 4 poles, 5 poles and 6 poles, respectively). The motor can be designed by the following steps.

1. Declare a number of rotor poles.
2. Declare a number of phases.
3. A total number of stator poles = [a number of rotor poles] \* [a number of phases].
4. Declare a number of stator teeth per pole. In this case, the invention is an overlap-pole type therefore a number of stator teeth per pole must be in accordance with the overlapping ratio (in 3 phase is  $1/3$  of pole width, in 4 phase is  $1/4$  of pole width and in 5 phase is  $1/5$  of pole width). A result of a number of stator teeth per pole divided by a number of phases should be an integer.
5. Minimum teeth per pole for a 3-phase overlap-pole type are 3 teeth to have  $1/3$  overlapping among 3 phases). To get a benefit over the invention of a low torque ripple should declare a high number of stator teeth per pole with optimising a practical winding
6. In 3 phases, the number of stator teeth per pole can be any integer number that is multiplied with 3, for examples 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36, 39, 42, etc.
7. In 4 phases, the number of stator teeth per pole can be any integer number that is multiplied with 4, for examples 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, etc.
8. A total number of stator teeth =  $[2/3] * [\text{A total number of stator poles}] * [\text{a number of stator teeth per pole}]$ .
9. A stroke angle of the invention =  $360 / \{[2/3] * [\text{A total number of stator poles}]\}$ .



10. A number of windings depend on a selected way of an invention winding (Fig.2, Fig.3 and Fig.4) and a number of stator teeth per pole.

As shown in Fig.15 the motor is 2-pole rotor, 3 phases and a number of stator teeth per pole are 15 teeth as a result:

A total number of stator poles =  $2 * 3 = 6$  poles.

A total number of stator teeth =  $[2/3] * 6 * 15 = 60$  teeth.

A stroke angle =  $360 / \{[2/3] * [A \text{ total number of stator poles}]\} = 360 / 4 = 90^\circ$ .

If selected way of invention windings is the same as Fig.2,

A total number of windings =  $[2/3] * 6 * 15 = 60$  windings.

Another examples of the invention structure, in Fig.16 the motor is 3-pole rotor, 3 phases and a number of stator teeth per pole are 9 teeth as a result:

A total number of stator poles =  $3 * 3 = 9$  poles.

A total number of stator teeth =  $[2/3] * 9 * 9 = 54$  teeth.

A stroke angle =  $360 / \{[2/3] * [A \text{ total number of stator poles}]\} = 360 / 6 = 60^\circ$ .

If selected way of invention windings is the same as Fig.2,

A total number of windings =  $[2/3] * 9 * 9 = 54$  windings.

The invention structure has a variety of configuration, as shown:

- In Fig. 17 a 4-pole 3-phase motor with stroke angle  $45^\circ$ ,
- In Fig. 18 a balancing torque 5-pole 3-phase motor with stroke angle  $36^\circ$ ,
- In Fig. 19 a 6-pole 3-phase motor with stroke angle  $30^\circ$ .

The invention has varieties of configurations. The examples of configurations that the invention can be applied are:

- A 7-pole 3-phase motor with stroke angle  $25.71^\circ$ ,
- A 8-pole 3-phase with stroke angle  $22.5^\circ$ ,
- A 9-pole 3-phase with stroke angle  $20^\circ$ ,
- A 10-pole 3-phase with stroke angle  $18^\circ$ ,
- A 11-pole 3-phase with stroke angle  $16.36^\circ$ ,
- A 12-pole 3-phase with stroke angle  $15^\circ$ ,
- Etc.

#### The overlap-pole type as AC machine

Unlike the switched reluctance motor, the invention structures can apply to the AC motor. However, to design the invention with the overlap-pole type in the AC machine has some limitation of configuration. The invention in overlap winding pole of AC motor, every winding pole has to invert the phase winding to each other adjacent to generate inverse circular flux loop rotation direction to each other adjacent in accordance with an alternating current. In addition, the motor has to use an even number of poles to maintain a balancing torque structure (for examples see Fig.20, Fig.21 and Fig.22, they are 2 poles, 4 poles and 6 poles, respectively). The invention in this configuration can be done by design steps as the overlap-pole type except every winding pole which 1/3 overlapping (in case of the 3-phase motor) are inversely wound the windings or invert the phase winding to each other adjacent (for example, Fig.20, +A, -B, +C, -A, +B and -C, respectively).

The speed of invention in AC motor can be calculated as a conventional AC motor.

$$\text{Speed} = 120[\text{frequency}]/[\text{a number of poles}] \dots \text{rpm}$$

The invention by this configuration can be only be an even number of poles of the rotor, for examples 2-pole, 4-pole, 6-pole, 8-pole, 10-pole, 12-pole, etc. The motor can be designed by the following steps:

1. Declare a number of poles of a rotor (only an even number of poles).
2. Declare a number of phases.
3. A total number of stator poles = [a number of rotor poles] \* [a number of phases].
4. Declare a number of stator teeth per pole. In this case, the invention is an overlap-pole type therefore a number of stator teeth per pole must be in accordance with the overlapping ratio (in 3 phase is 1/3 of pole width, in 4 phase is 1/4 of pole width and in 5 phase is 1/5 of pole width). A result of a number of stator teeth per pole divided by a number of phases should be an integer.
5. Minimum teeth per pole for a 3-phase overlap-pole type are three teeth to have 1/3 overlapping among 3 phases).
6. In 3 phases, the number of stator teeth per pole can be declared in any integer number that is multiplied with 3, for examples 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36, 39, 42, etc.
7. In 4 phases, the number of stator teeth per pole can be declare is any integer number that is multiplied with 4, for examples 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, etc.
8. To get a benefit over the invention of a low torque ripple should declare a high number of stator teeth per pole with optimising a practical winding.
9. A total number of stator teeth =  $[2/3] * [A \text{ total number of stator poles}] * [a \text{ number of stator teeth per pole}]$ .
10. A stroke angle of the invention =  $360 / \{[2/3] * [A \text{ total number of stator poles}]\}$ .
11. A number of windings depend on a selected way of an invention winding and a number of stator teeth per pole.
12. The invention in overlap winding pole of AC motor, every winding pole has to invert the phase winding to each other adjacent (to generate inverse circular flux loop rotation direction to each other adjacent) to be in accordance with alternating current, for example phase windings in 3-phase 2-pole are +A, -B, +C, -A, +B and -C, respectively.

The invention has varieties of configurations. The examples of configurations that the invention can be applied are:

- A 2-pole 3-phase motor with a stroke angle 90°,
- A 4-pole 3-phase motor with a stroke angle 45°,
- A 6-pole 3-phase motor with a stroke angle 30°,
- A 8-pole 3-phase with a stroke angle 22.5°,
- A 10-pole 3-phase with a stroke angle 18°,
- A 12-pole 3-phase with a stroke angle 15°,
- Etc.

## DRAWING DESCRIPTION OF THE INVENTION

- **Fig.2:** A simple one pole of the invention (Every tooth of a stator pole are wound), all windings are connected together and are one phase excitation
- **Fig.3:** A simple one pole of the invention (Every odd tooth of a stator pole are wound), all windings are connected together and are one phase excitation
- **Fig.4:** A simple one pole of the invention (Every even tooth of a stator pole are wound), all windings are connected together and are one phase excitation
- **Fig.5:** A torque profile of the invention compare to a prior art: torque of 9 teeth (31); total torque (32); prior art torque (33)
- **Fig.6a:** A simple 3-phase of the invention (non-overlap-pole type): configuration for an odd number of stator teeth per pole (9 teeth)
- **Fig.6b:** A simple 3-phase of the invention (non-overlap-pole type): configuration for an even number of stator teeth per pole (8 teeth)
- **Fig.7a:** the best mode of the invention, an overlap-pole type as DC PULSE machine, each phase are separated and some teeth have more than one phase
- **Fig.7b:** the best mode of the invention, an overlap-pole type as AC machine, each phase are separated and some teeth have more than one phase
- **Fig.8a:** The current direction of the winding related to the multi-circular flux loops rotation direction, all windings are connected together and are one phase excitation
- **Fig.8b:** The invention in term of a toothless-stator machine, all windings are connected together and are one phase excitation
- **Fig.9a:** The 3-phase DC pulse motor: each phase are separated and some slot have more than one phase; first row is phase C; second row is phase B; third row is phase A
- **Fig.9b:** The 3-phase AC motor: each phase are separated and some slot have more than one phase; first row is phase C; second row is phase B; third row is phase A.
- **Fig.10:** The simple invention in a term of a linear motor: 2 stator/rotor sets (40), a 1 phase winding, 5 teeth with windings per pole (42), 1 rotor/stator pole (41), the multi-circular flux loops (44), the most effective circular flux (46) and a direction of movement (45). All flux rotation direction create by winding are inverse to each other adjacent.
- **Fig.11a:** A 3-phase motor with non-overlap-pole type, a phase A (47a), a phase B (47b), a phase C (47c), a rotor/stator (48) and a rotor/stator support (49).
- **Fig.11b:** A 3-phase motor with non-overlap-pole type with a pole space, a phase A (50a), a phase B (50b), a phase C (50c), a rotor/stator (51) and a rotor/stator support (52).
- **Fig.11c:** A 3-phase motor with non-overlap-pole type without a pole space, a phase A (50a), a phase B (50b), a phase C (50c), a rotor/stator (51) and a rotor/stator support (52). NOTE: In case of a number of stator teeth per pole are even number, there are no inverse phase winding.
- **Fig.11d:** A 3-phase motor with 4-pole rotor (97), similar function to a 6/4-pole switched reluctance motor, 5 teeth with winding per pole, stator frame (98), motor shaft (100) and rotor core (99).
- **Fig.12:** A 2-pole (93), a 3-phase motor with non-overlap-pole type, 10 winding teeth with windings per pole, stator frame (94), motor shaft (96) and rotor core (95)
- **Fig.13:** A 3-pole (57), a 3-phase motor with non-overlap-pole type, 6 teeth with windings per pole, stator frame (58), motor shaft (60) and rotor core (59)
- **Fig.14:** A 4-pole (53), a 3-phase motor with non-overlap-pole type, 5 teeth with windings per pole, stator frame (54), motor shaft (56) and rotor core (55)
- **Fig.15:** A 2-pole (61), a 3-phase DC pulse motor with overlap-pole type, 15 teeth with windings per pole, stator frame (62), motor shaft (64) and rotor core (63)

- **Fig.16:** A 3-pole (65), a 3-phase DC pulse motor with overlap-pole type, 9 teeth with windings per pole, stator frame (66), motor shaft (68) and rotor core (67)
- **Fig.17:** A 4-pole (69), a 3-phase DC pulse motor with overlap-pole type, 9 teeth with windings per pole, stator frame (70), motor shaft (72) and rotor core (71)
- **Fig.18:** A 5-pole (73), a 3-phase DC pulse motor with overlap-pole type, 6 teeth with windings per pole, stator frame (74), motor shaft (76) and rotor core (75)
- **Fig.19:** A 6-pole (77), a 3-phase DC pulse motor with overlap-pole type, 6 teeth with windings per pole, stator frame (78), motor shaft (80) and rotor core (79)
- **Fig.20:** A 2-pole (81), a 3-phase AC motor with overlap-pole type, 15 teeth with windings per pole, stator frame (82), motor shaft (84) and rotor core (83)
- **Fig.21:** A 4 poles (85), a 3-phase AC motor with overlap-pole type, 9 teeth with windings per pole, stator frame (86), motor shaft (88) and motor core (87)
- **Fig.22:** A 6 poles (89), a 3-phase AC motor with overlap-pole type, 6 teeth with windings per pole, stator frame (90), motor shaft (92) and motor core (91)
- **Fig.23:** The waveform for the invention: (a) A waveform for a 3-phase non-overlap-pole type (DC pulse machine); (b) A waveform for a 3-phase overlap-pole type (DC pulse machine); (c) A waveform for a 3-phase overlap-pole type (AC machine)

\*Please note that the motor core may not be necessary if the design circumstance does not concern about torque per weight therefore the motor core can be the rotor lamination area.

## CLAIMS

## 1. An invention comprises of the following:

- Windings on a stator and no windings on a rotor;
- The rotor and the stator are salient pole;
- The rotor pole width is about the stator pole width;
- Each stator pole (a winding pole) is subdivided into plural stator teeth;
- All windings of the plural stator teeth of each stator pole are connected together to be one phase winding;
- The phase winding of each stator pole is excited to perform electromagnetic poles;
- All odd stator teeth of each stator pole are either North poles or South poles;
- All even stator teeth of each stator pole are either North poles or South poles;
- The electromagnetic poles of the odd stator teeth and the even stator teeth are opposite;
- Each stator tooth generates linking flux loops to both adjacent teeth to complete its electromagnetic flux loops;
- The both adjacent teeth are a right-hand adjacent tooth and a left-hand adjacent tooth;
- The electromagnetic flux loops of the stator tooth consist of a left-hand linking flux loop and a right-hand linking flux loop;
- The left-hand linking flux loop is either a left or right rotation direction;
- The right-hand linking flux loop is either a left or right rotation direction;
- The left-hand linking flux loop of the odd stator teeth and the right-hand linking flux loop of the even stator teeth are the same rotation direction;
- The right-hand linking flux loop of the odd teeth and the left-hand linking flux of the even teeth are the same rotation direction;
- The linking flux loops are joined together as a series of flux loops (a series of circular flux loops);
- The flux loop where a rotor pole-corner is aligned with the stator pole produces reluctance torque to rotate or move the rotor pole, then the next flux loop where the rotor pole-corner is increasingly aligned with the stator pole produces reluctance torque to continue rotate or move until the rotor pole is fully aligned with the stator pole;
- Using both plural winding poles and plural phases perform a poly-phase machine that can be done by two combining types, (i) a non-overlap-pole type is done by placing the winding pole of the next phase next to the winding pole of the present phase in consideration of the both ends of the series of flux loops between phases at a pole joint must be the same rotation direction, and (ii) an overlap-pole type is done by overlapping the winding poles of plural phases in consideration of the series of flux loops where the plural phases are overlapped must be the same rotation direction.

2. An invention according to claim 1, by changing both the rotor to be the stator and the stator to be the rotor creates an invention which comprises of the following:
- Windings on a rotor and no windings on a stator;
  - The rotor and the stator are salient pole;
  - The rotor pole width is about the stator pole width;
  - Each rotor pole (a winding pole) is subdivided into plural rotor teeth;
  - All windings of the plural rotor teeth of each rotor pole are connected together to be one phase winding;
  - The phase winding of each rotor pole is excited to perform electromagnetic poles;
  - All odd rotor teeth of each rotor pole are either North poles or South poles;
  - All even rotor teeth of each rotor pole are either North poles or South poles;
  - The electromagnetic poles of the odd rotor teeth and the even rotor teeth are opposite;
  - Each rotor tooth generates linking flux loops to both adjacent teeth to complete its electromagnetic flux loops;
  - The both adjacent teeth are a right-hand adjacent tooth and a left-hand adjacent tooth;
  - The electromagnetic flux loops of the rotor tooth consist of a left-hand linking flux loop and a right-hand linking flux loop;
  - The left-hand linking flux loop is either a left or right rotation direction;
  - The right-hand linking flux loop is either a left or right rotation direction;
  - The left-hand linking flux loop of the odd rotor teeth and the right-hand linking flux loop of the even rotor teeth are the same rotation direction;
  - The right-hand linking flux loop of the odd rotor teeth and the left-hand linking flux of the even rotor teeth are the same rotation direction;
  - The linking flux loops are joined together as a series of flux loops (a series of circular flux loops);
  - The flux loop where a stator pole-corner is aligned with the rotor pole produces reluctance torque to rotate or move the rotor pole, then the next flux loop where the stator pole-corner is increasingly aligned with the rotor pole produces reluctance torque to continue rotate or move until the stator pole is fully aligned with the rotor pole;
  - Using both plural winding poles and plural phases perform a poly-phase machine that can be done by two combining types, (i) a non-overlap-pole type is done by placing the winding pole of the next phase next to the winding pole of the present phase in consideration of the both ends of the series of flux loops between phases at a pole joint must be the same rotation direction, and (ii) an overlap-pole type is done by overlapping the winding poles of plural phases in consideration of the series of flux loops where the plural phases are overlapped must be the same rotation direction.

3. An invention according to claim 1 wherein said, all windings of the plural stator teeth of each stator pole and in claim 2 wherein said, all windings of the plural rotor teeth of each rotor pole, the windings are all connected in either series or parallel to be one phase winding and can be wound by three ways:
  - The phase winding, every tooth is wound inversely direction to each other adjacent;
  - The phase winding, only the odd teeth are wound and wound in the same direction;
  - The phase winding, only the even teeth are wound and wound in the same direction.
4. An invention according to claim 3 wherein said, every tooth is wound inversely direction to each other adjacent, another method can be done by every tooth is wound in the same direction and every winding terminal is inverted polarity to each other adjacent.
5. An electrical machine according to claim 1 wherein said, the plural stator teeth, can be replaced with an invisible teeth to be a toothless-stator machine by the invention technique:
  - The invention can work without the stator tooth on the stator pole but the rotor pole have to be very close to the toothless-stator pole;
  - The winding space on the stator is still necessary to perform as the invisible tooth for flux travelling between the stator pole and the rotor pole.
6. An electrical machine according to claim 2 wherein said the plural rotor teeth, can be replace with an invisible teeth to be a toothless-rotor machine by the invention technique:
  - The invention can work without the rotor tooth on the rotor pole but the stator pole have to be very close to the toothless-rotor pole;
  - The winding space on a rotor is still necessary to perform as the invisible tooth for flux travelling between the stator pole and the rotor pole.

7. An electrical machine according to claim 1, a poly-phase machine of the invention by the non-overlap-pole type as Direct Current pulse machine,  
The invention by this type can be either odd or even number of rotor poles, for examples 2 poles, 3 poles, 4 poles, 5 pole, 6 poles, 7 poles, 8 poles, 9 poles, 10 poles, 11 poles, 12 poles, etc, and can be designed by the following steps:

- Declare a number of rotor poles;
- Declare a number of stator teeth;
- In case of, a number of stator teeth per pole is even number the invention configuration can be either an even or odd number of the rotor poles;
- In case of, a number of stator teeth per pole is odd number the invention configuration can only be an even rotor pole number and every winding pole has to invert the phase winding to each other adjacent to eliminate cancellation of the series of flux loops, for example the phase windings in 3-phase 2-pole are (+A), (-B), (+C), (-A), (+B) and (-C), respectively;
- Declare a number of phases;
- A total number of stator poles = [a number of rotor poles] \* [a number of phases];
- A total number of stator teeth = [a total number of stator poles] \* [a number of stator teeth per pole];
- Minimum number of teeth per pole for the non-overlap-pole type are two teeth to generate a one short flux loop between teeth and two short flux loops at the both ends of the series of flux loops;
- To get the benefit over the invention of a low torque ripple should declare a high number of stator teeth per pole with optimising a practical winding;
- A stroke angle of the invention =  $360 / \{[2/3] * [A \text{ total number of stator poles}]\}$ ;
- A number of windings depend on a selected way of the invention winding and a number of stator teeth per pole;
- The invention has varieties of configurations, the examples of configurations that the invention can apply to are,
  - A 2-pole 3-phase motor with stroke angle  $60^\circ$ ,
  - A 3-pole 3-phase motor with stroke angle  $40^\circ$ ,
  - A 4-pole 3-phase motor with stroke angle  $30^\circ$ ,
  - A 5-pole 3-phase motor with stroke angle  $24^\circ$ ,
  - A 6-pole 3-phase motor with stroke angle  $20^\circ$ ,
  - A 7-pole 3-phase motor with stroke angle  $17.14^\circ$ ,
  - A 8-pole 3-phase motor with stroke angle  $15^\circ$ ,
  - A 9-pole 3-phase motor with stroke angle  $13.33^\circ$ ,
  - A 10-pole 3-phase motor with stroke angle  $12^\circ$ ,
  - A 11-pole 3-phase motor with stroke angle  $10.09^\circ$ ,
  - A 12-pole 3-phase motor with stroke angle  $10^\circ$ ,
  - Etc.



8. An electrical machine according to claim 1, a poly-phase machine of the invention by the overlap-pole type as Direct Current pulse machine,  
The invention by this configuration can be any odd or even number of rotor poles, for examples 2 poles, 3 poles, 4 poles, 5 poles, 6 poles, 7 poles, 8 poles, 9 poles, 10 poles, 11 poles, 12 poles, etc, and can be designed by the following steps:

- Declare a number of rotor poles;
- Declare a number of phases;
- A total number of stator poles = [a number of rotor poles] \* [a number of phases];
- Declare a number of stator teeth per pole;
- A number of stator teeth per pole must be in accordance with the overlapping ratio (in 3 phase is 1/3 of pole width, in 4 phase is 1/4 of pole width, in 5 phase is 1/5 of pole width, etc);
- The result of a number of stator teeth per pole divided by a number of phases should be an integer;
- Minimum teeth per pole for a 3-phase overlap-pole type are 3 teeth to have 1/3 overlapping among 3 phases, a 4-phase overlap-pole type are 4 teeth to have 1/4 overlapping among 4 phases, etc;
- In 3 phases, the number of stator teeth per pole can be any integer number that is multiplied with 3, for examples 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36, 39, 42, etc;
- In 4 phases, the number of stator teeth per pole can be any integer number that is multiplied with 4, for examples 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, etc;
- To get a benefit over the invention of a low torque ripple should declare a high number of stator teeth per pole with optimising a practical winding;
- A total number of stator teeth =  $[2/3] * [A \text{ total number of stator poles}] * [a \text{ number of stator teeth per pole}]$ ;
- A stroke angle of the invention =  $360 / \{[2/3] * [A \text{ total number of stator poles}]\}$ ;
- A number of windings depend on a selected way of the invention windings and a number of stator teeth per pole;
- The invention has varieties of configurations, the examples of configurations that the invention can apply to are,
  - A 2-pole 3-phase motor with stroke angle 90°,
  - A 3-pole 3-phase motor with stroke angle 60°,
  - A 4-pole 3-phase motor with stroke angle 45°,
  - A 5-pole 3-phase motor with stroke angle 36°,
  - A 6-pole 3-phase motor with stroke angle 30°,
  - A 7-pole 3-phase motor with stroke angle 25.71°,
  - A 8-pole 3-phase with stroke angle 22.5°,
  - A 9-pole 3-phase with stroke angle 20°,
  - A 10-pole 3-phase with stroke angle 18°,
  - A 11-pole 3-phase with stroke angle 16.36°,
  - A 12-pole 3-phase with stroke angle 15°,
  - Etc.

9. An electrical machine according to claim 1, a poly-phase machine of the invention by the overlap-pole type as Alternating Current machine,  
The invention by this configuration can be only an even number of poles of a rotor, for examples 2 poles, 4 poles, 6 poles, 8 poles, 10 poles, 12 poles, etc, and can be designed by the following steps:

- Declare a number of poles of a rotor (only an even number of poles);
- Declare a number of phases;
- A total number of stator poles = [a number of rotor poles] \* [a number of phases];
- Declare a number of stator teeth per pole;
- A number of stator teeth per pole must be in accordance with the overlapping ratio (in 3 phase is 1/3 of pole width, in 4 phase is 1/4 of pole width, in 5 phase is 1/5 of pole width, etc);
- A result of a number of stator teeth per pole divided by a number of phases should be an integer;
- Minimum teeth per pole for a 3-phase overlap-pole type are 3 teeth to have 1/3 overlapping among 3 phases, a 4-phase overlap-pole type are 4 teeth to have 1/4 overlapping among 4 phases, etc;
- In 3 phases, the number of stator teeth per pole can be any integer number that is multiplied with 3, for examples 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36, 39, 42, etc;
- In 4 phases, the number of stator teeth per pole can be any integer number that is multiplied with 4, for examples 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, etc;
- To get a benefit over the invention of a low torque ripple should declare a high number of stator teeth per pole with optimising a practical winding;
- A total number of stator teeth =  $[2/3] * [A \text{ total number of stator poles}] * [a \text{ number of stator teeth per pole}]$ ;
- A stroke angle of the invention =  $360 / \{[2/3] * [A \text{ total number of stator poles}]\}$ ;
- A number of windings depend on a selected way of an invention winding and a number of stator teeth per pole;
- The invention in the overlap-pole type of AC motor, every winding pole has to invert the phase winding to each other adjacent to generate the series of flux loops rotation direction in accordance with alternating current to eliminate cancellation of the series of flux loops, for example phase windings in 3-phase 2-pole are (+A), (-B), (+C), (-A), (+B) and (-C), respectively;
- The invention has varieties of configurations, the examples of configurations that the invention can apply to are,
  - A 2-pole 3-phase motor with stroke angle 90°,
  - A 4-pole 3-phase motor with stroke angle 45°,
  - A 6-pole 3-phase motor with stroke angle 30°,
  - A 8-pole 3-phase with stroke angle 22.5°,
  - A 10-pole 3-phase with stroke angle 18°,
  - A 12-pole 3-phase with stroke angle 15°,
  - Etc.

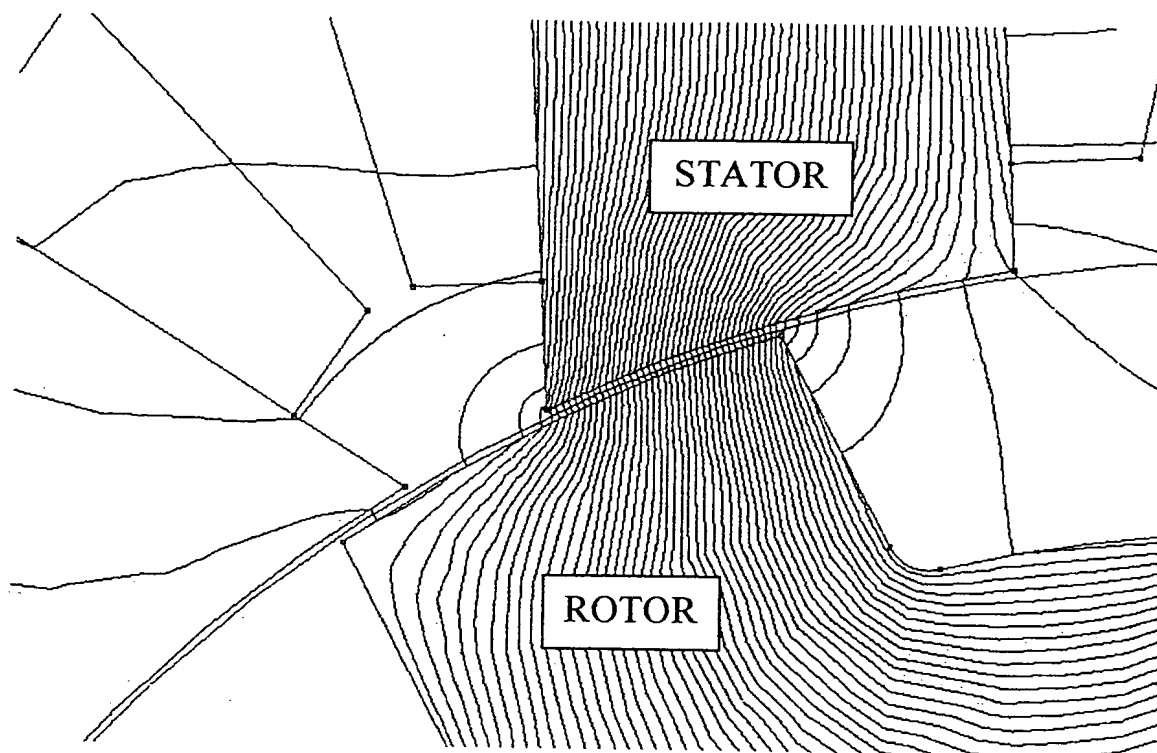
10. An electrical machine according to claim 2 wherein said, windings on a rotor and no windings on a stator, and wherein said, a poly-phase machine, by using invention method of claim 7 and claim 8 and claim 9 creates a poly-phase electrical machine that windings on the rotor and no windings on the stator.
11. A linear motor unfolds from the invention of claim 7, claim 8, claim 9 and claim 10.
12. An invention according to claim 1 wherein said, Each stator tooth generates linking flux loops to both adjacent teeth to complete their electromagnetic flux loops, means flux loops travel only between the both adjacent teeth, therefore the rotor core can be improved by the following methods:
  - The rotor core can be replaced with a light weight material to be a lightweight rotor;
  - The rotor core can be hollowed out to be a lightweight rotor.

.....

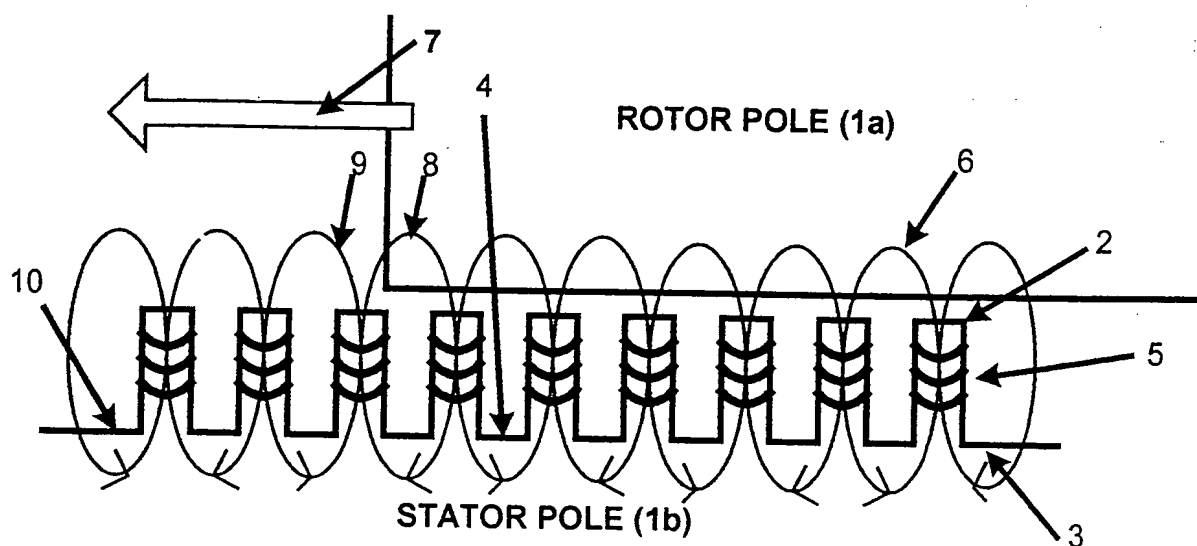
## MULTI-CIRCULAR FLUX MOTOR

### *ABSTRACT*

An invention is a new type of motor, a multi-circular flux motor. The invention has simple structure and comprises of a salient pole rotor and the silent pole stator. The stator pole is subdivided into plural teeth with the individual winding. A group of windings of each stator pole is connected in either series or parallel and is driven by one excitation phase. The movement of the invention uses multi-circular flux loops to produce reluctance torque to make the rotor moves. The multi-circular flux loops comprise of a series of flux loops that every flux loop is inversely rotation direction to each other adjacent. The invention can apply in a linear and rotating machine. By having plural winding poles and phases, the invention can be a poly-phase machine. The invention can be designed to be any number of poles and phases because all flux loops are separated. The invention is applied in both AC and DC machine and both linear and rotating machine. The rotor core can be replaced with a lightweight material or hollowed out to be a lightweight rotor. The invention can be designed to be a toothless-stator or toothless-rotor machine.



**Fig.1 A flux density of one phase excitation (Prior Art)**



**Fig.2**



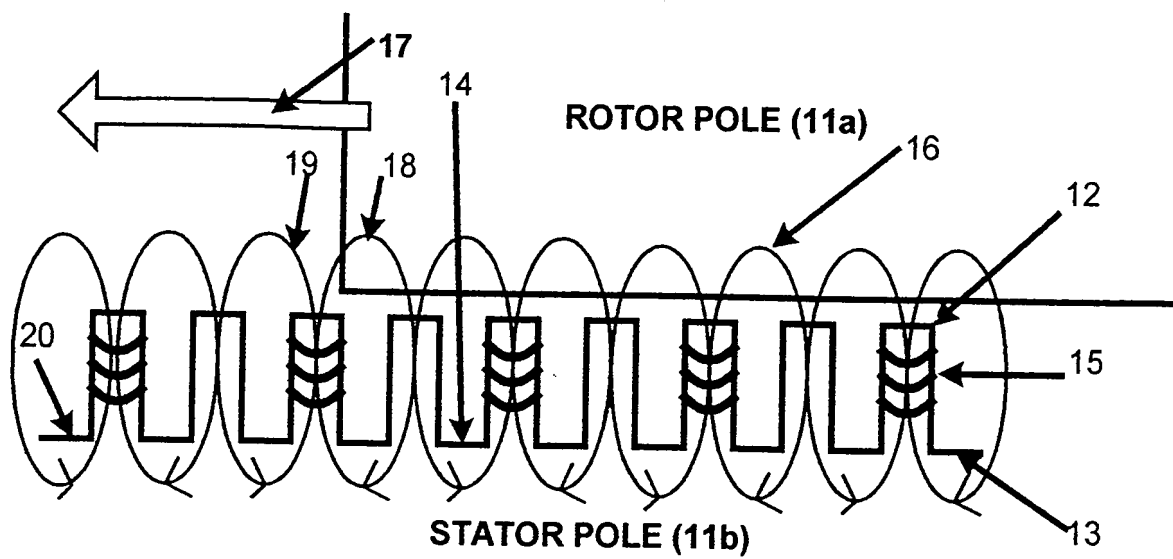


Fig.3

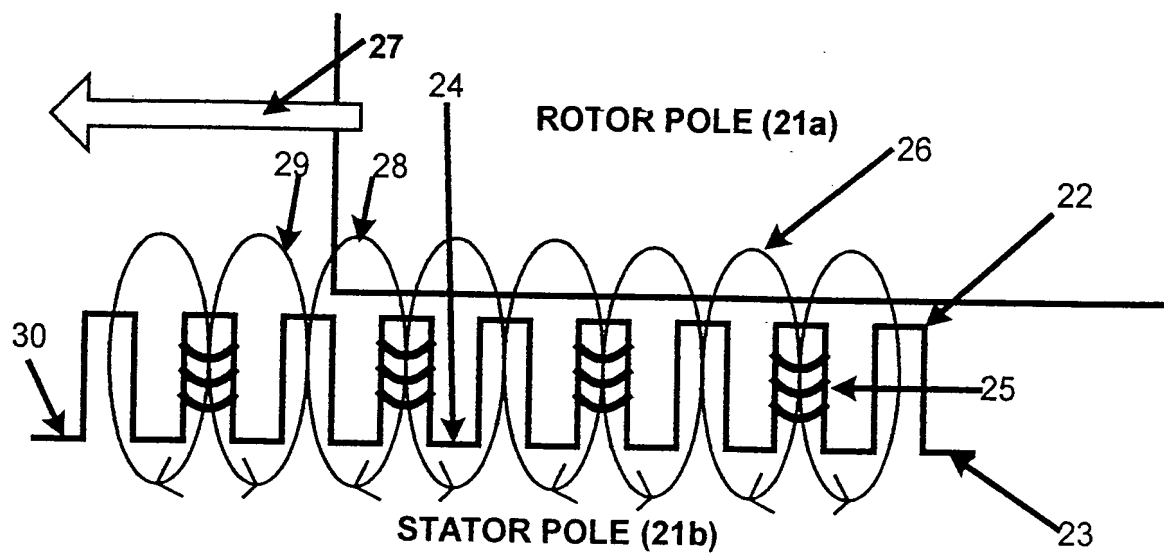


Fig.4





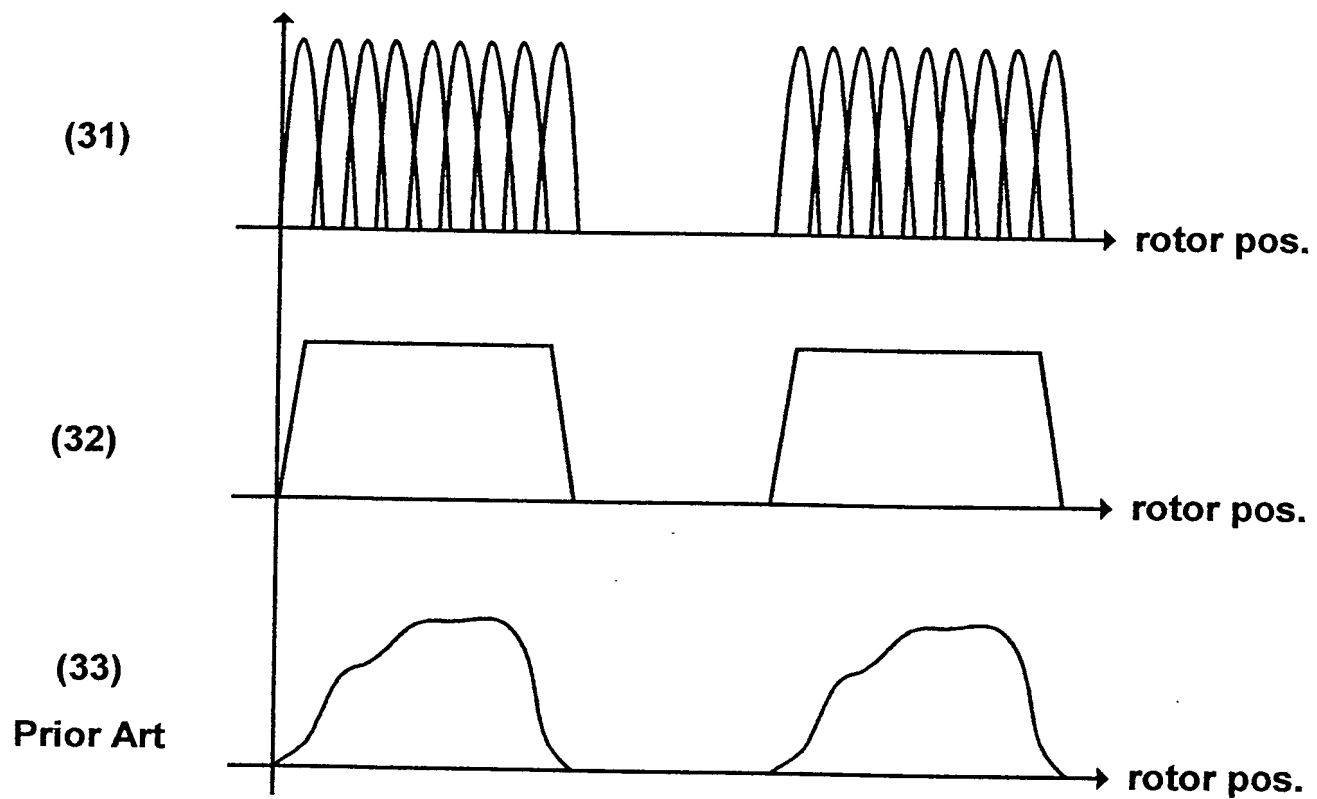
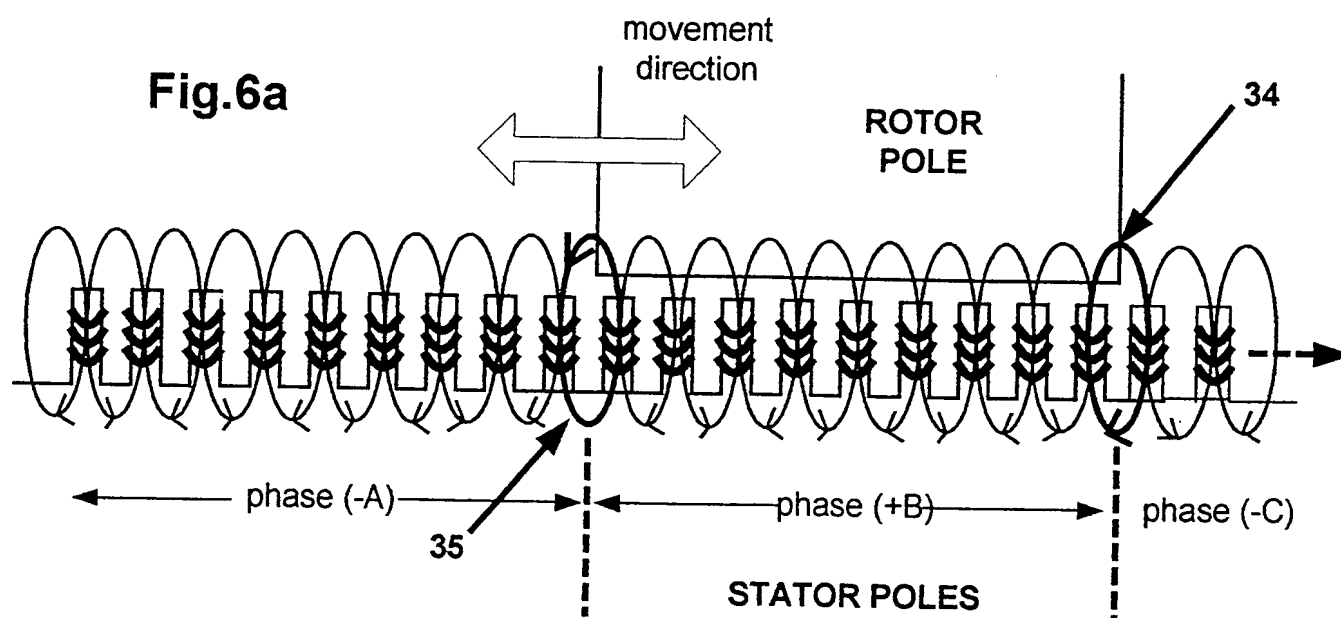
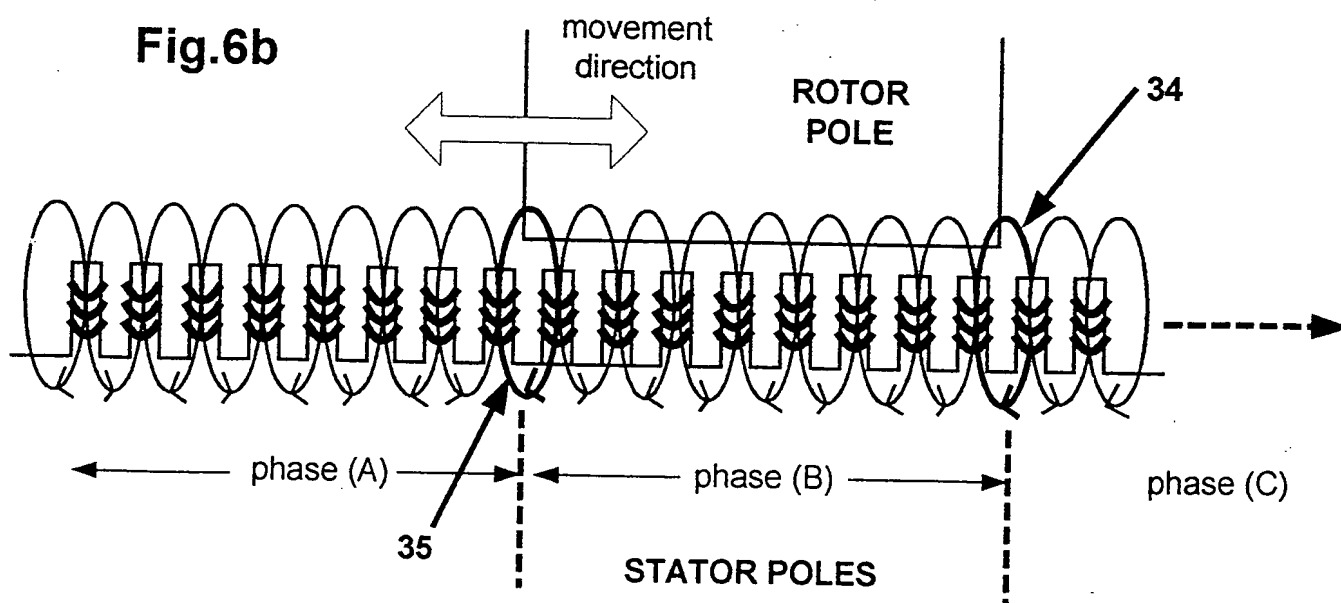


Fig.5



**Fig.6a****Fig.6b**



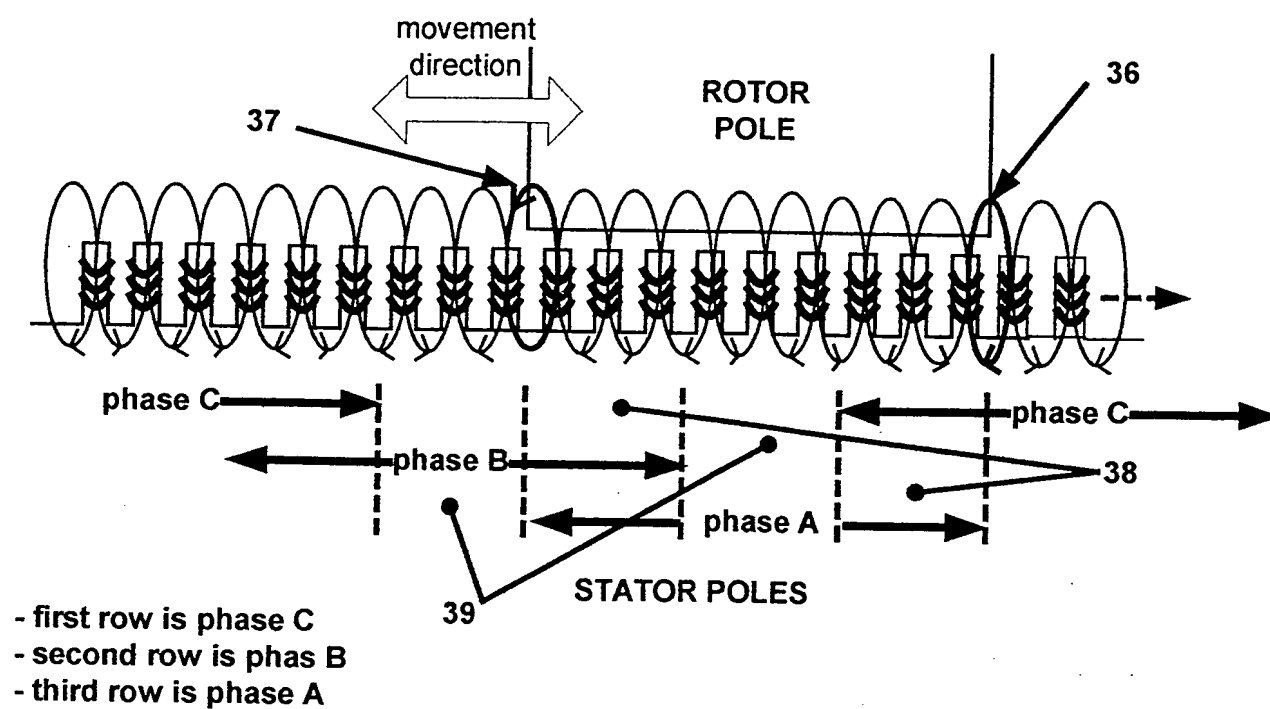


Fig.7a

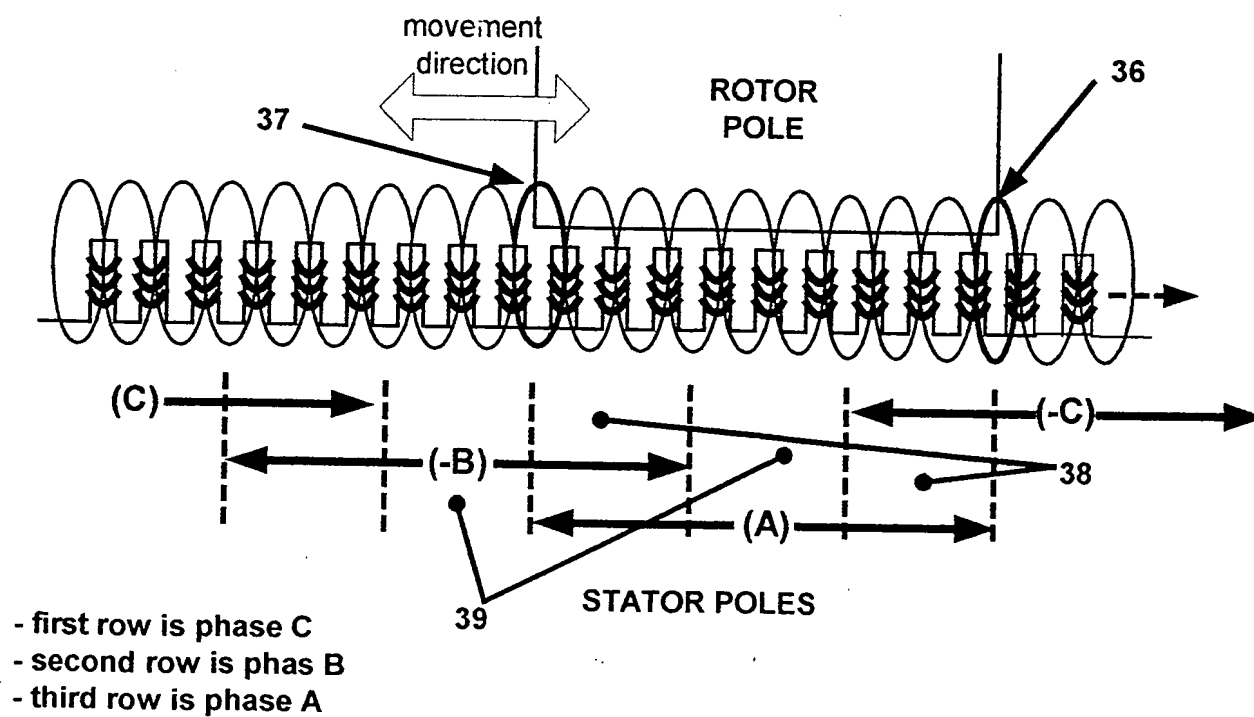


Fig.7b



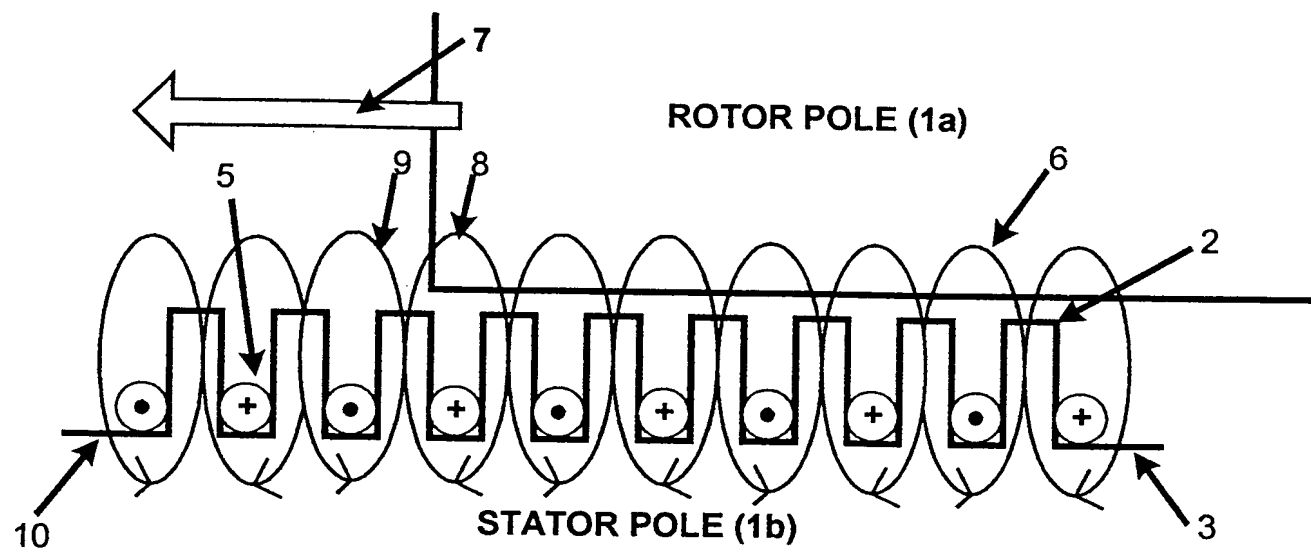


Fig.8a

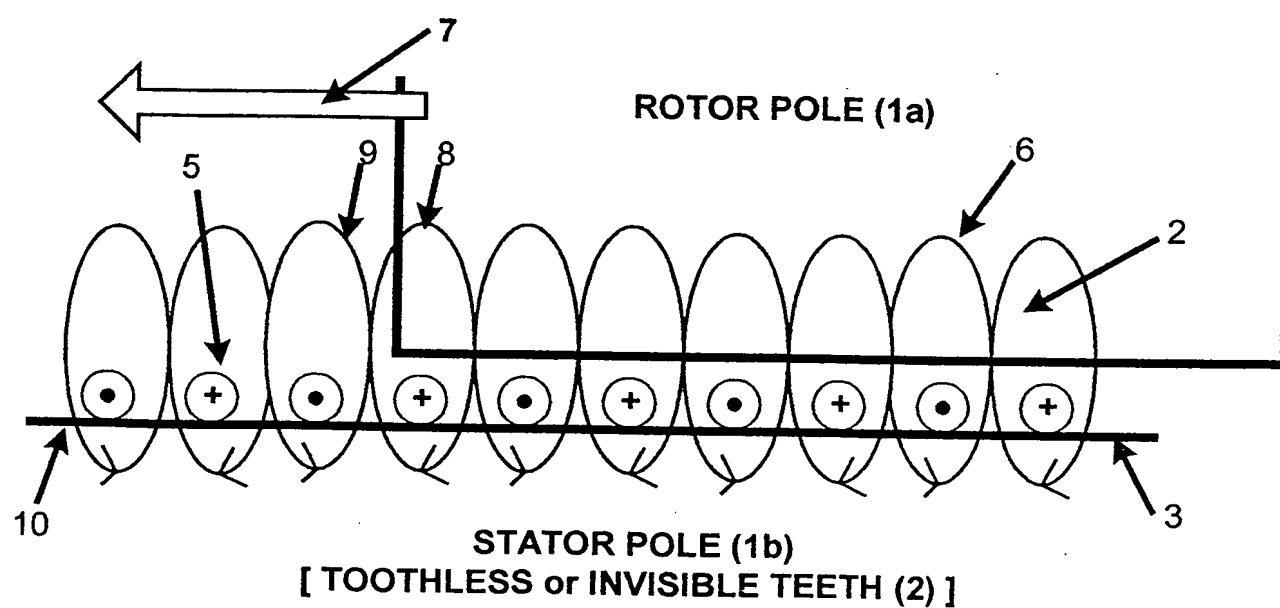


Fig.8b





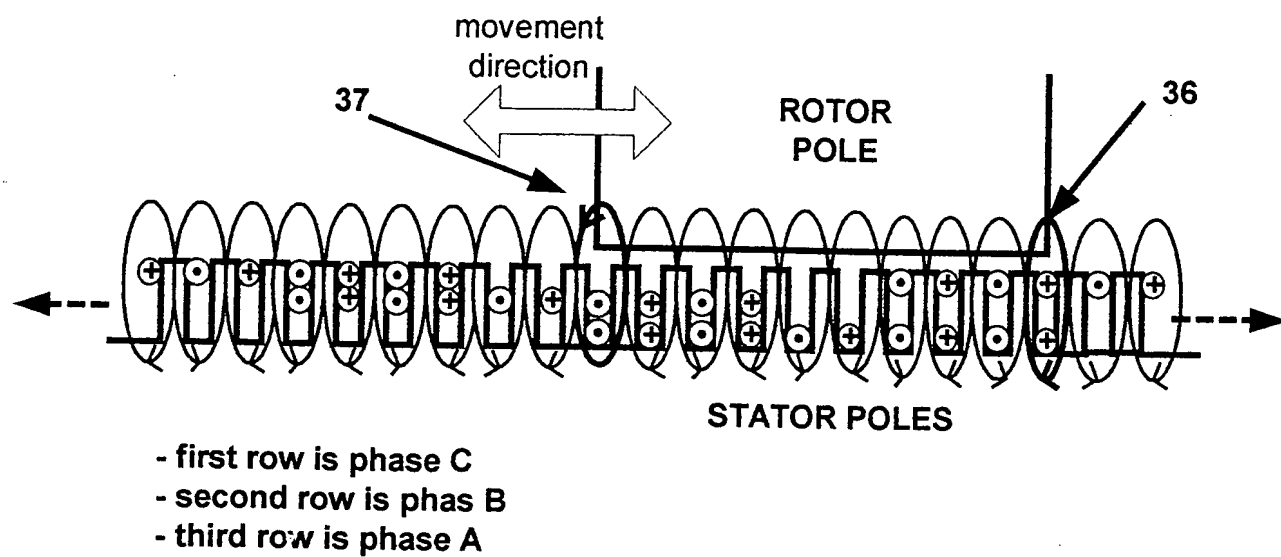


Fig.9a

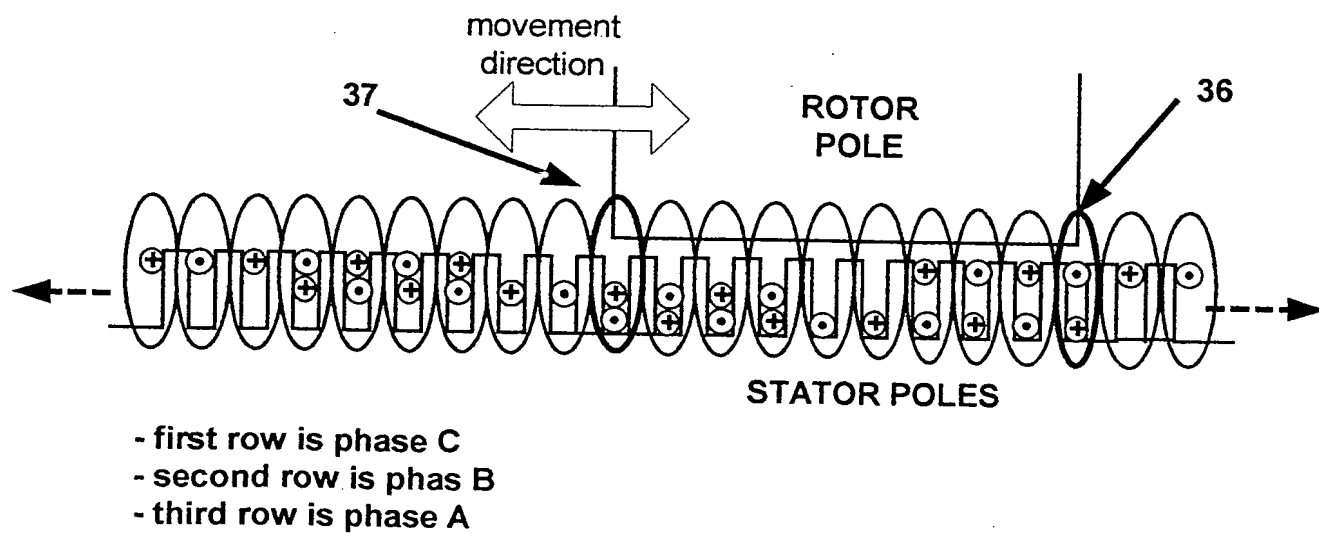


Fig.9b



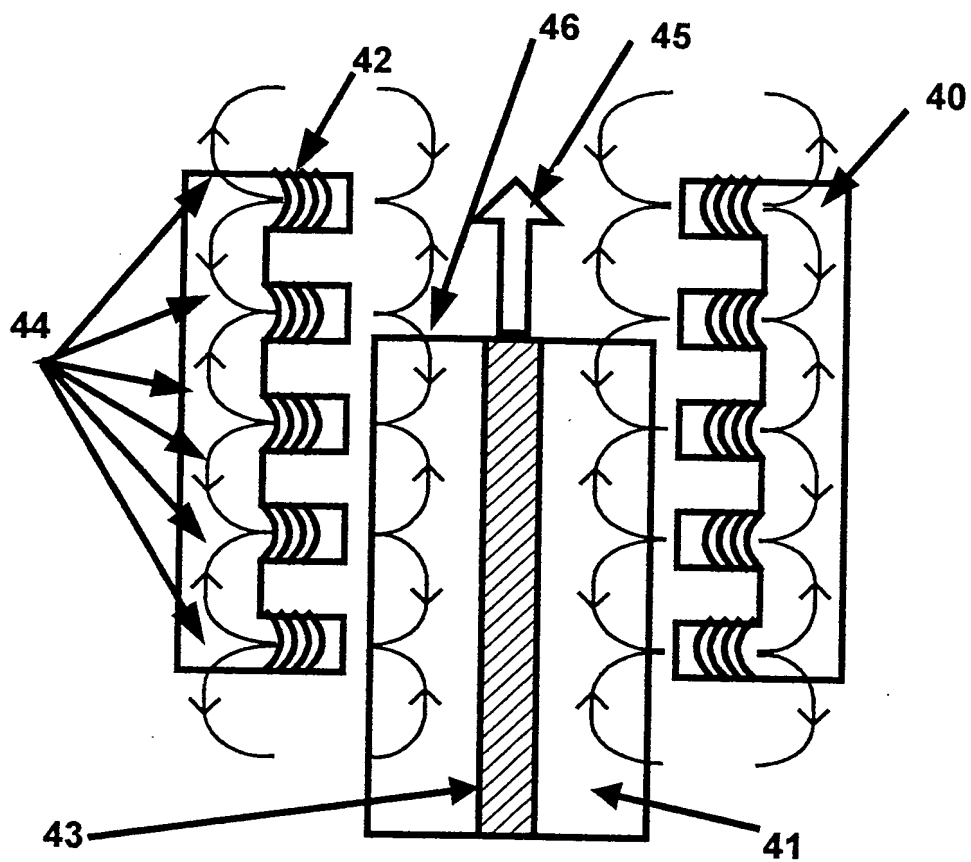


Fig.10



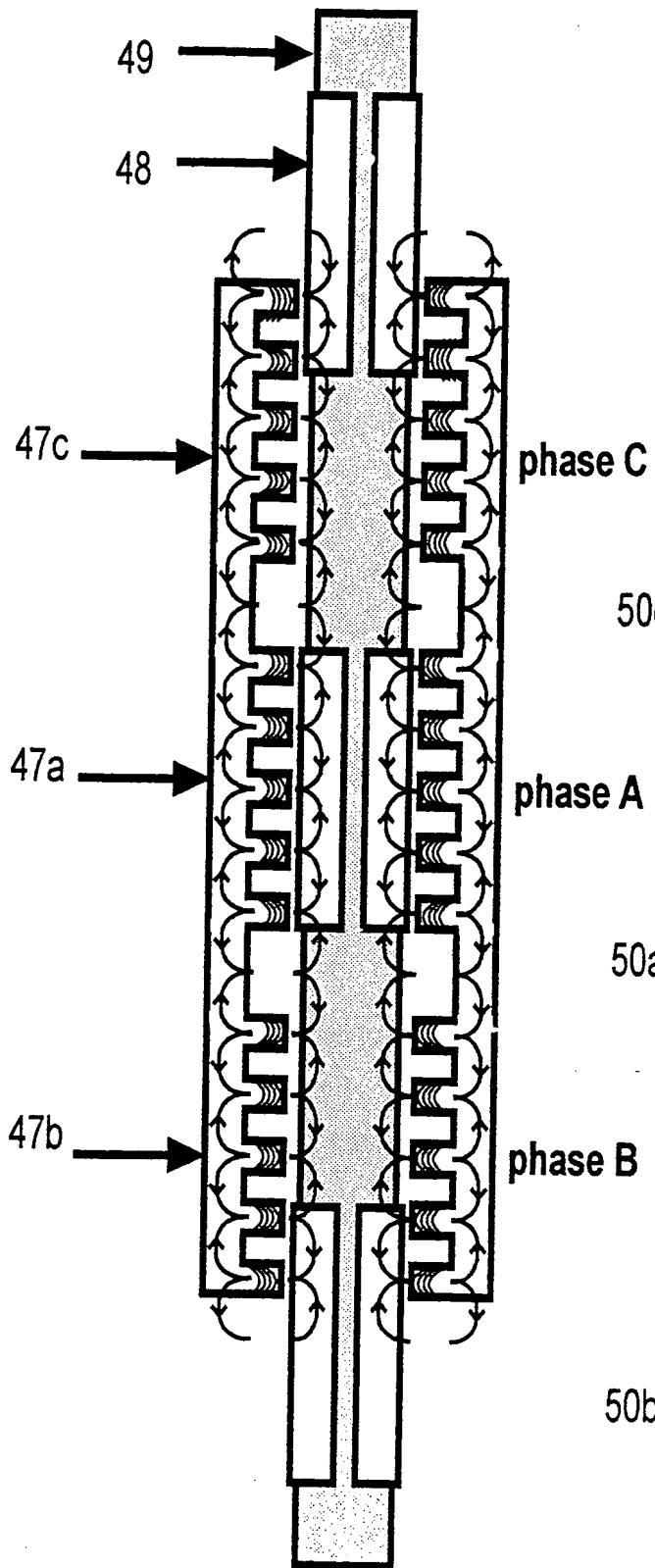


Fig. 11a

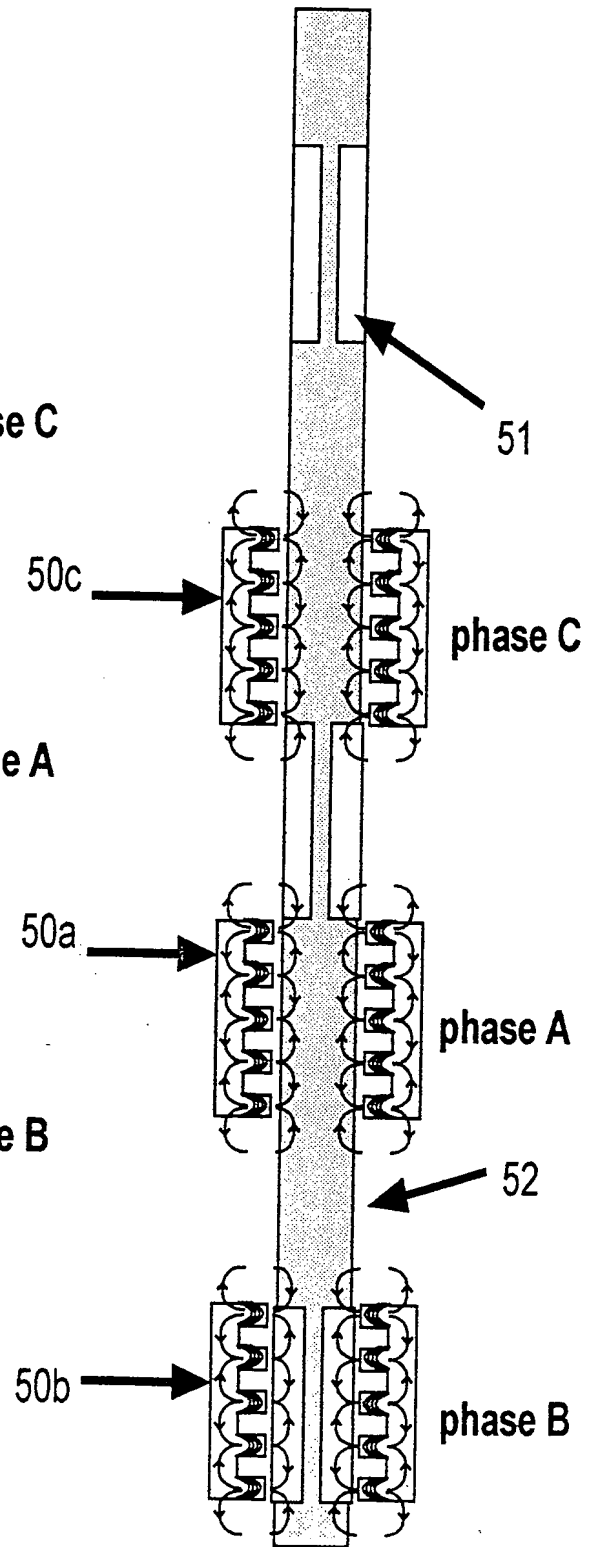
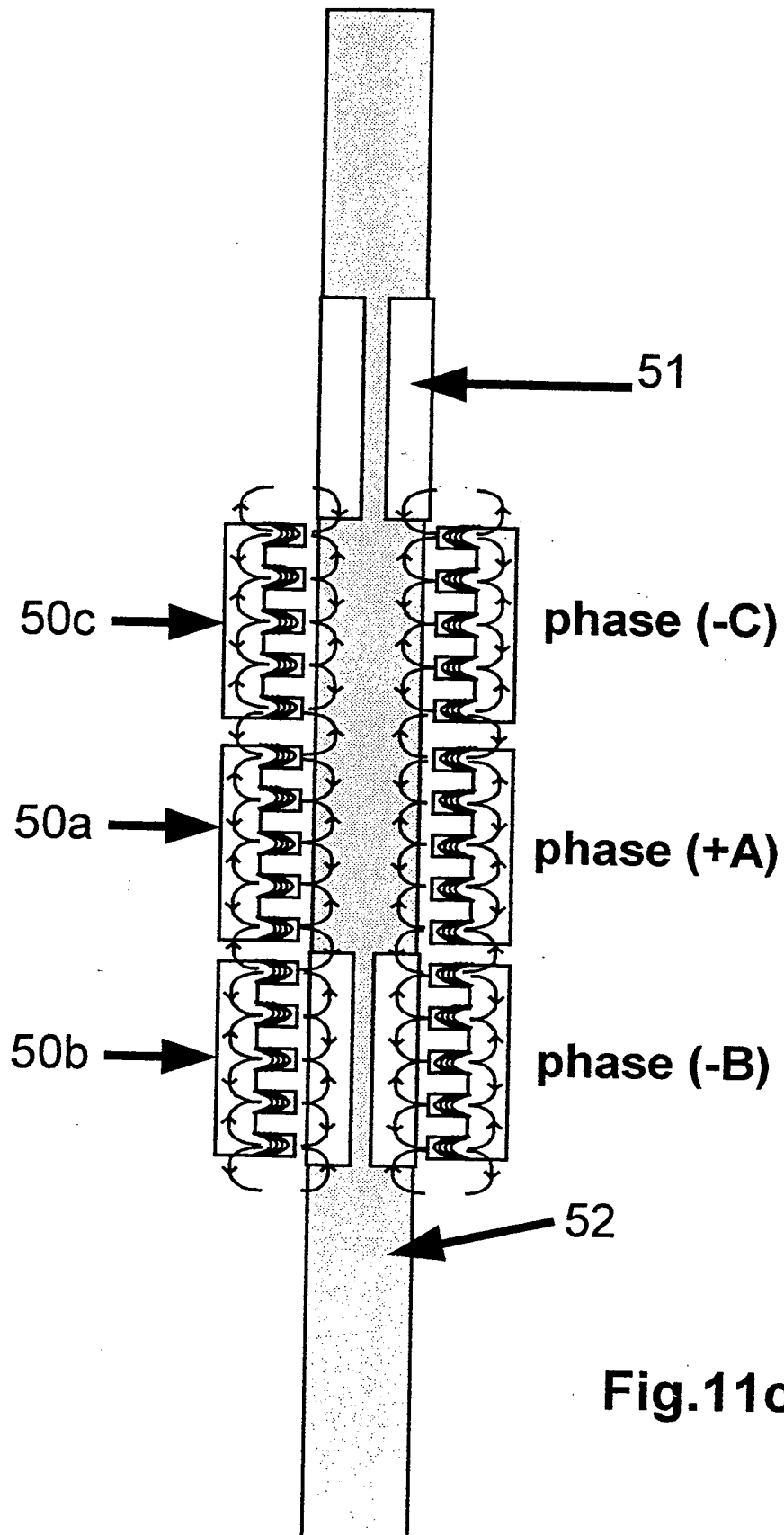


Fig. 11b



**Fig.11c**





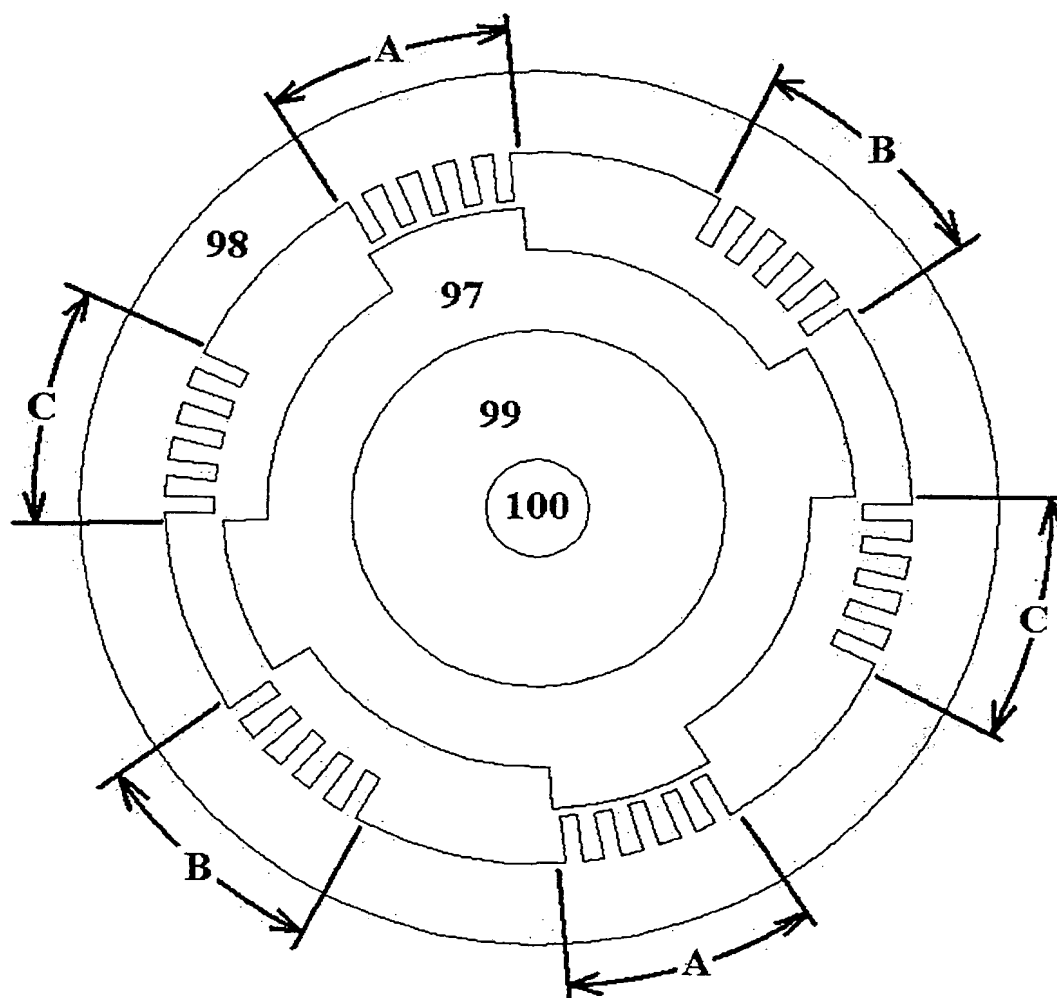


Fig.11d



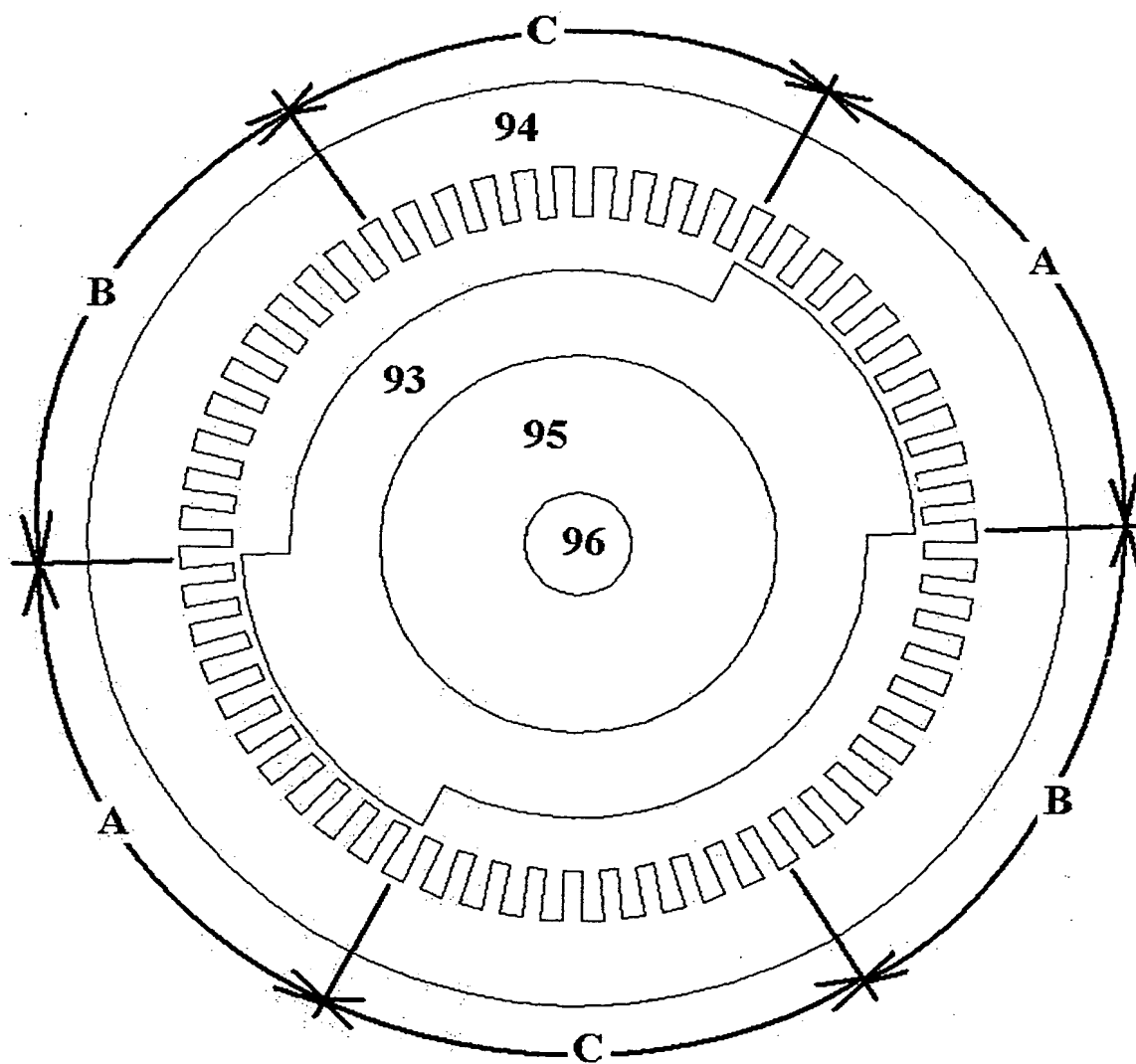


Fig.12



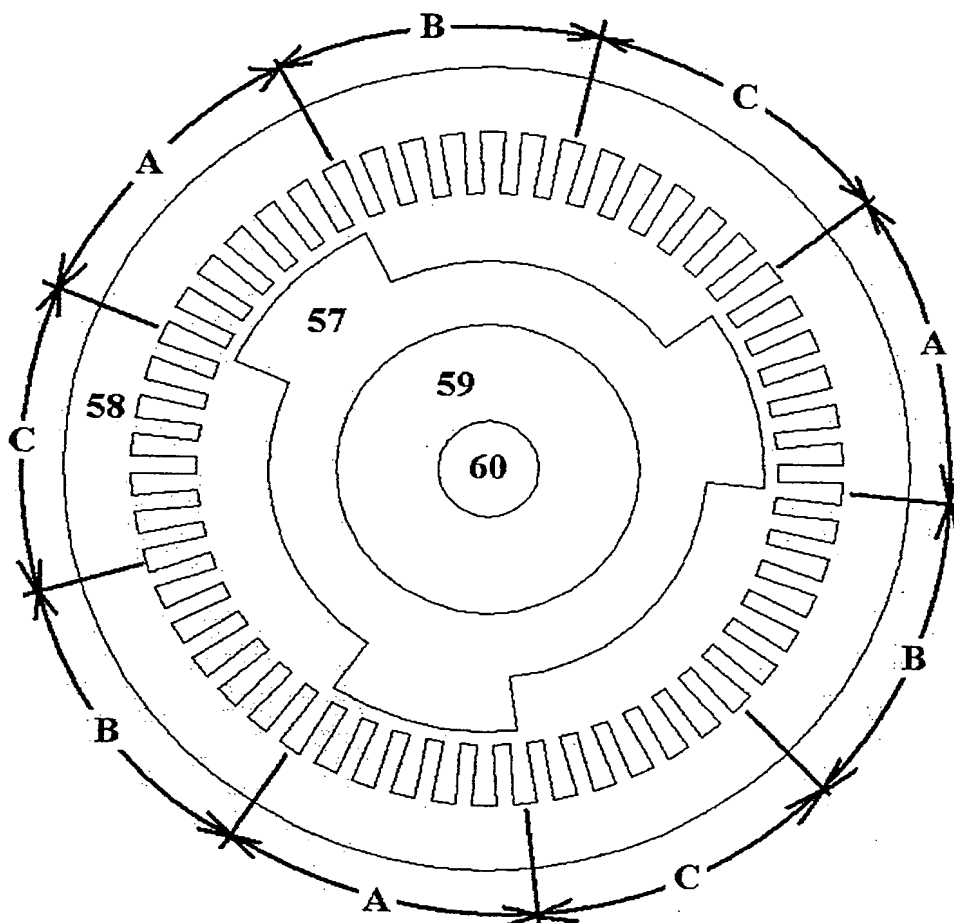


Fig.13



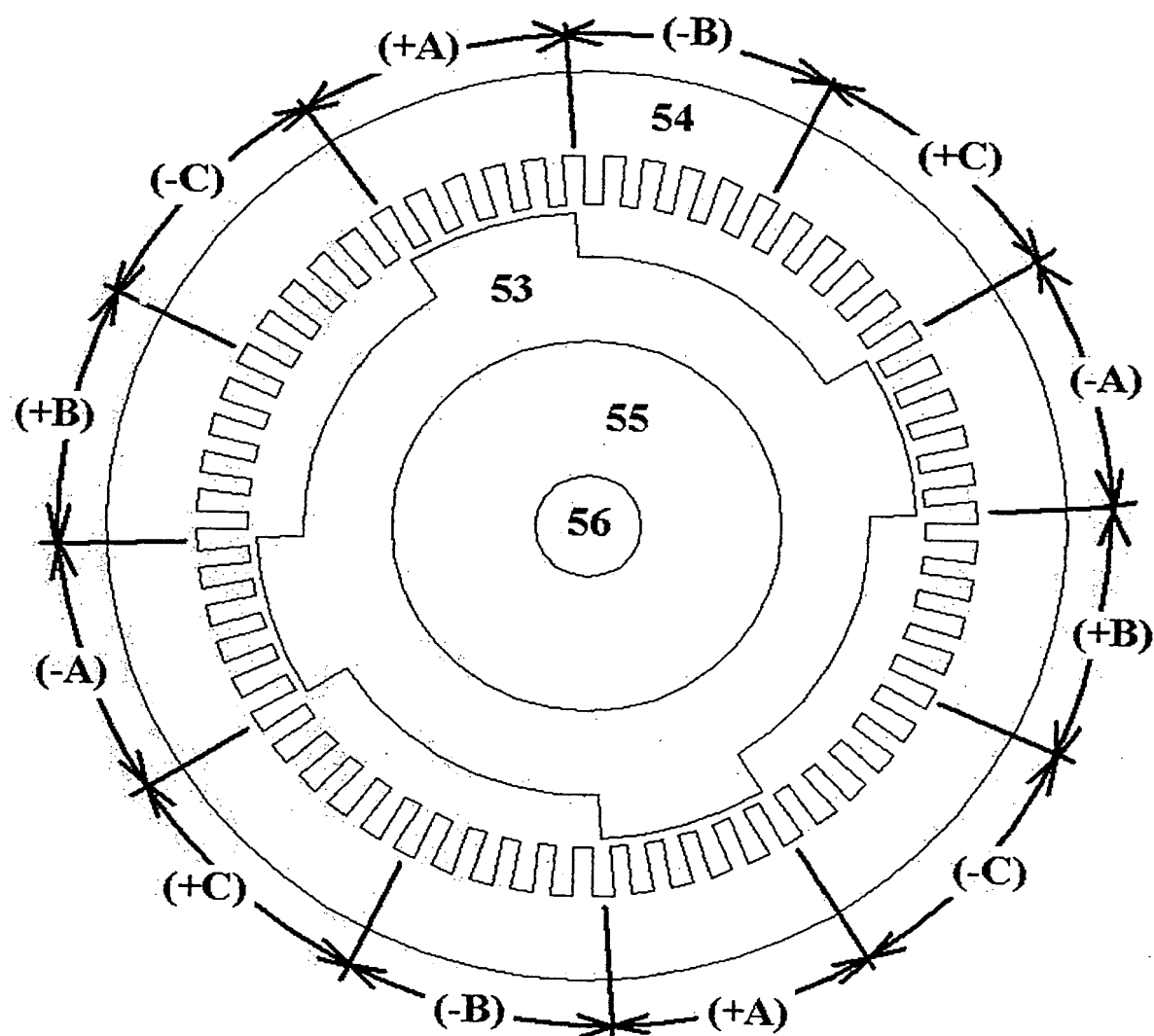
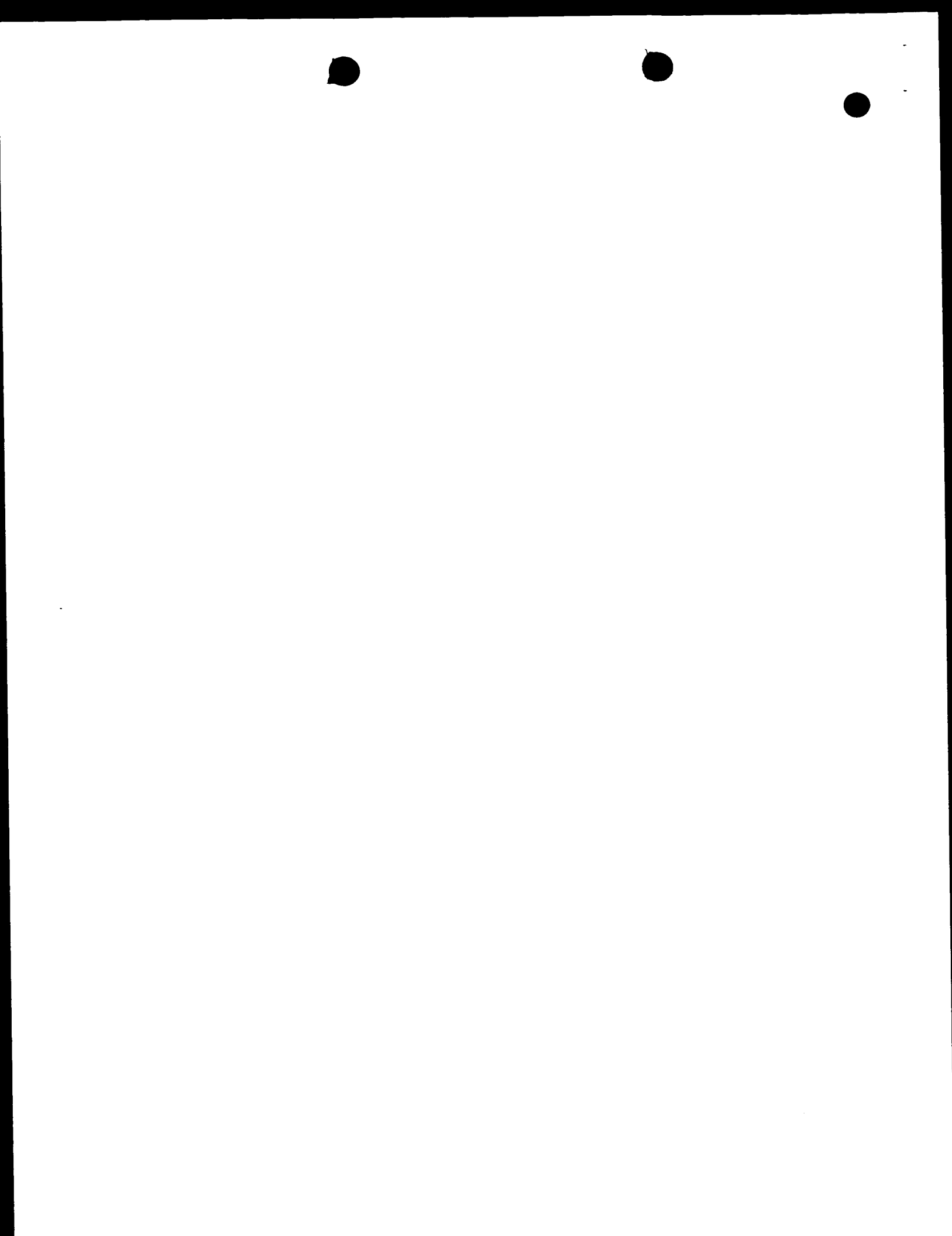


Fig.14





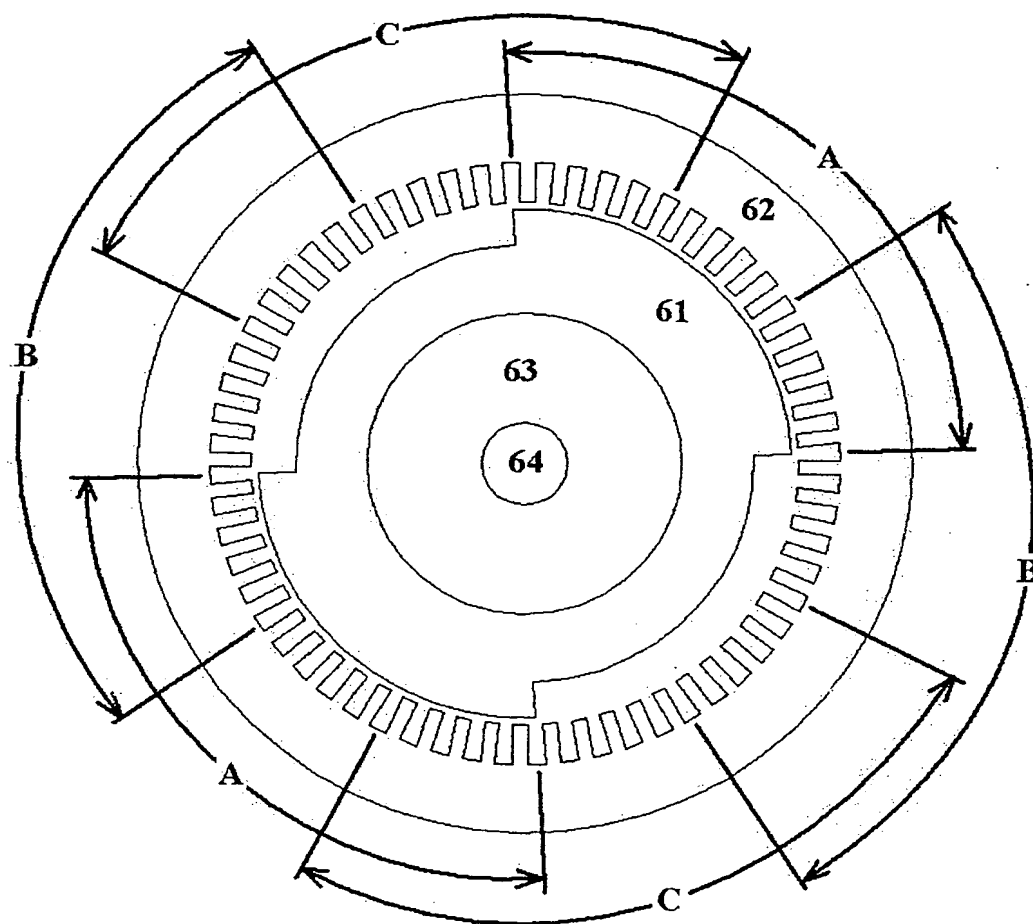
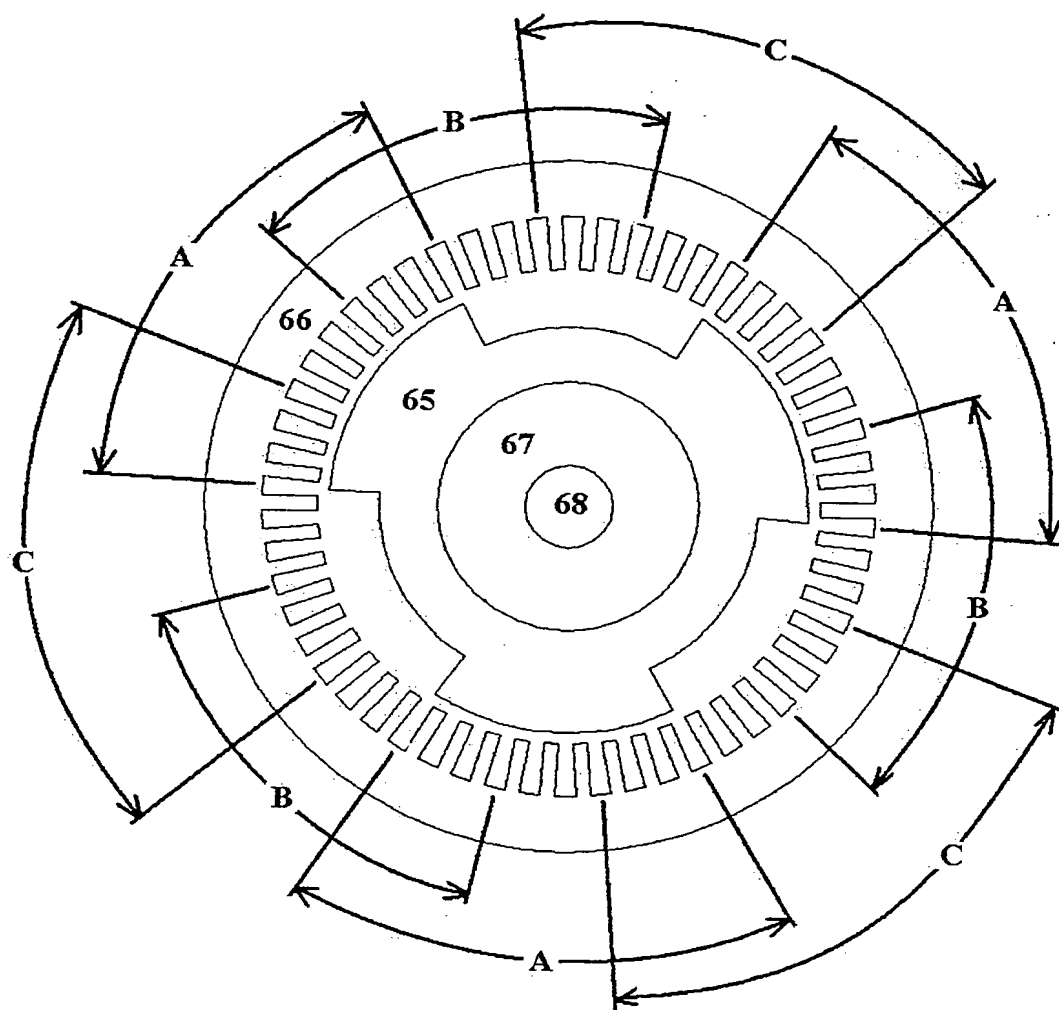


Fig.15





**Fig.16**



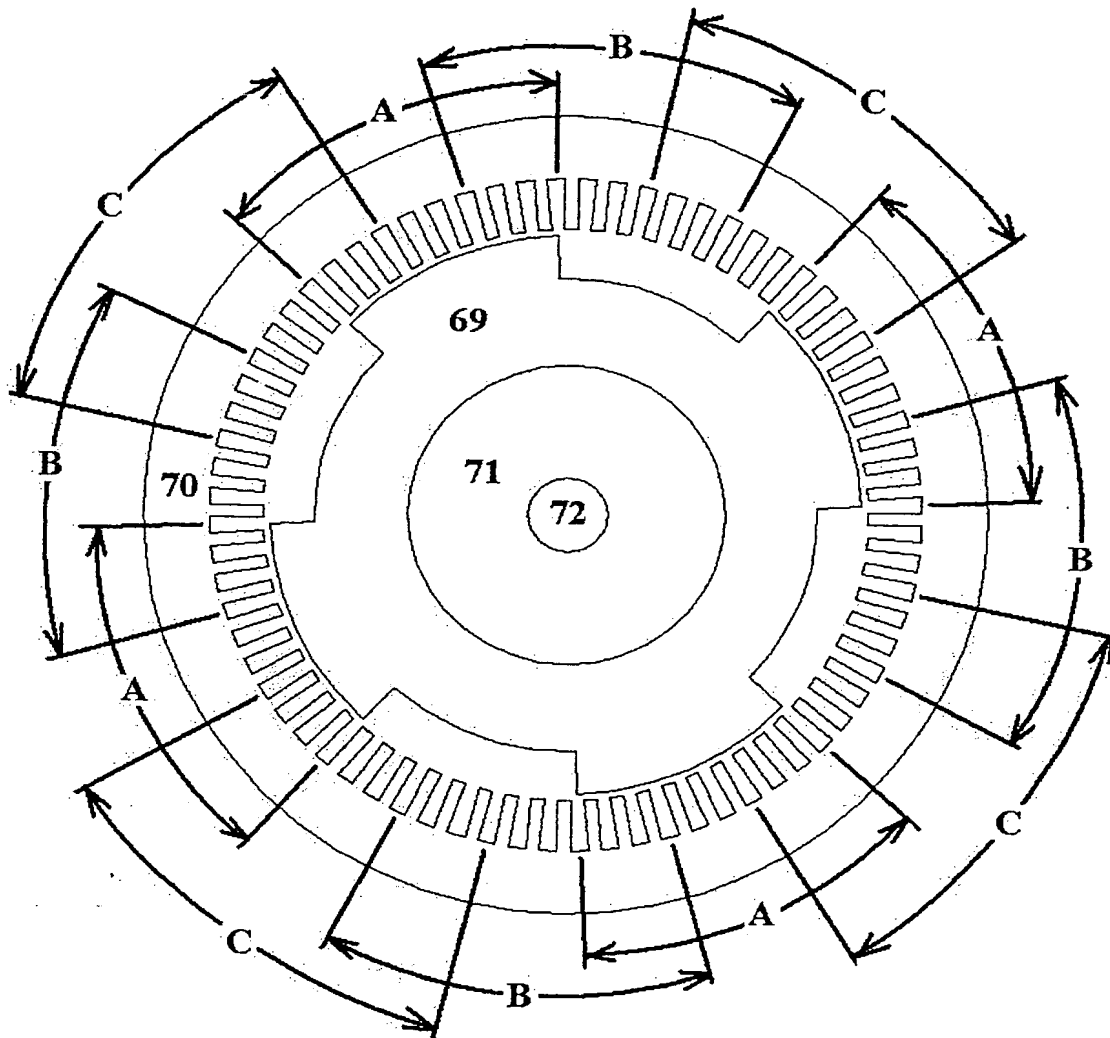


Fig.17









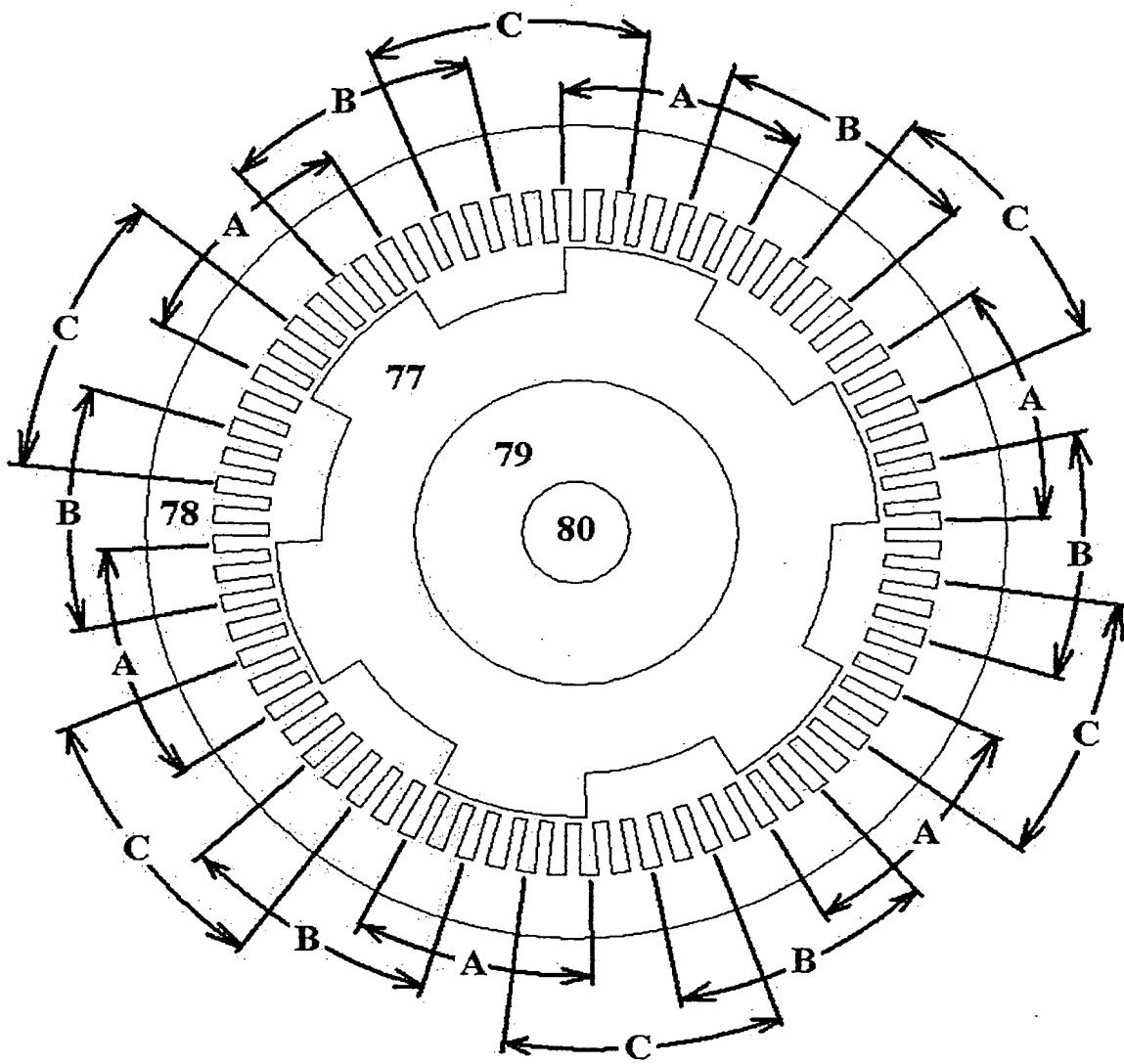


Fig. 19



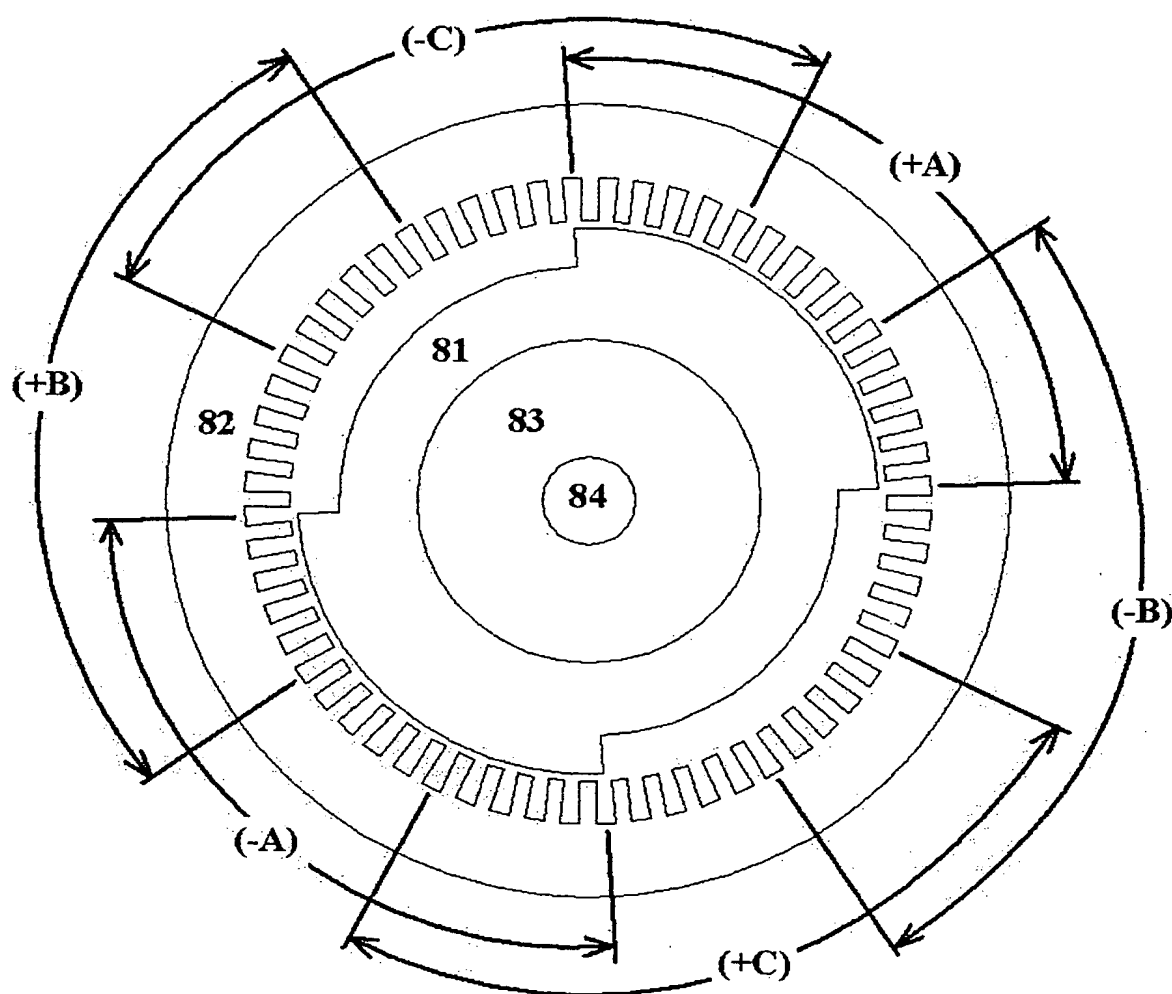


Fig.20



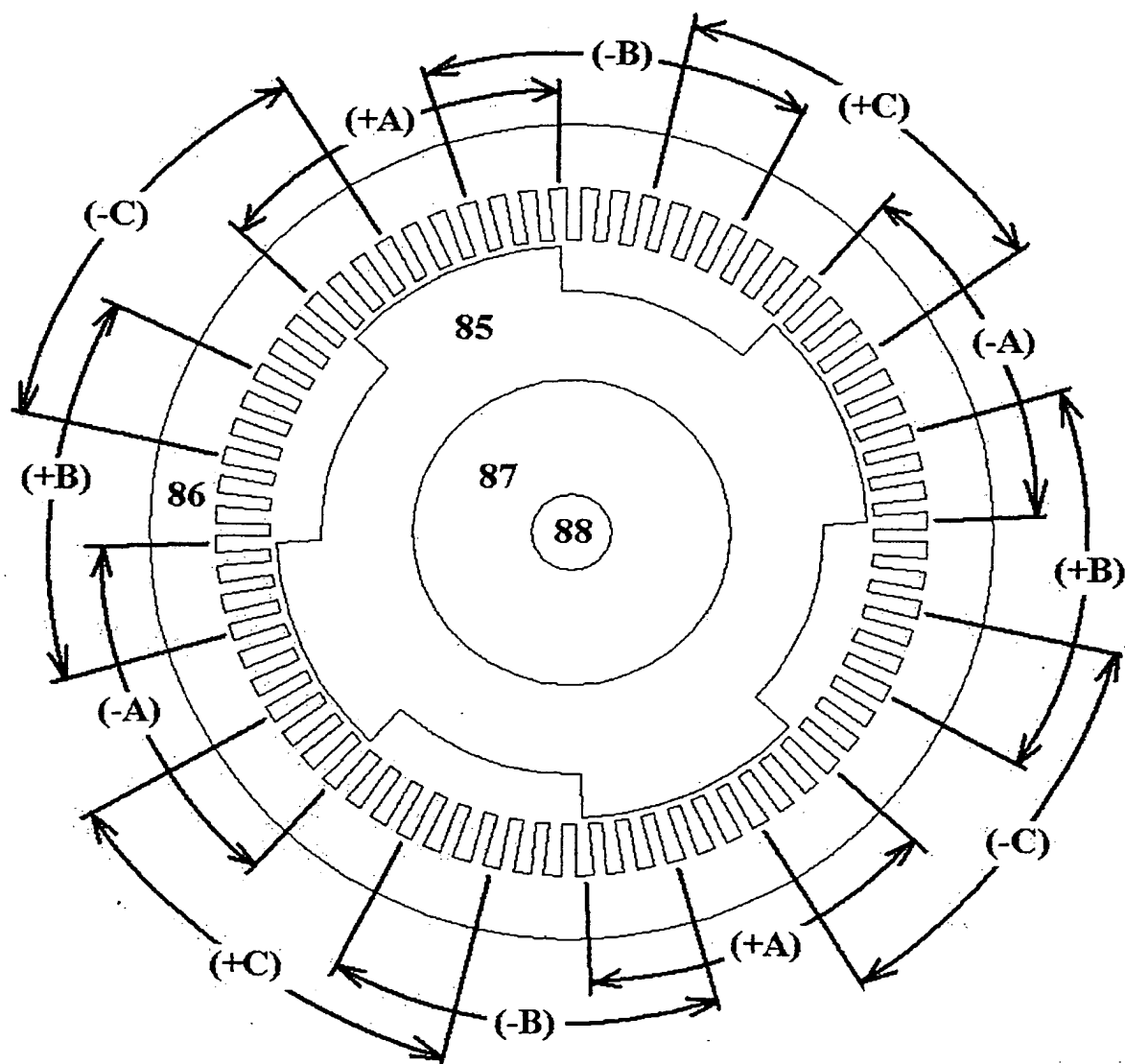


Fig.21



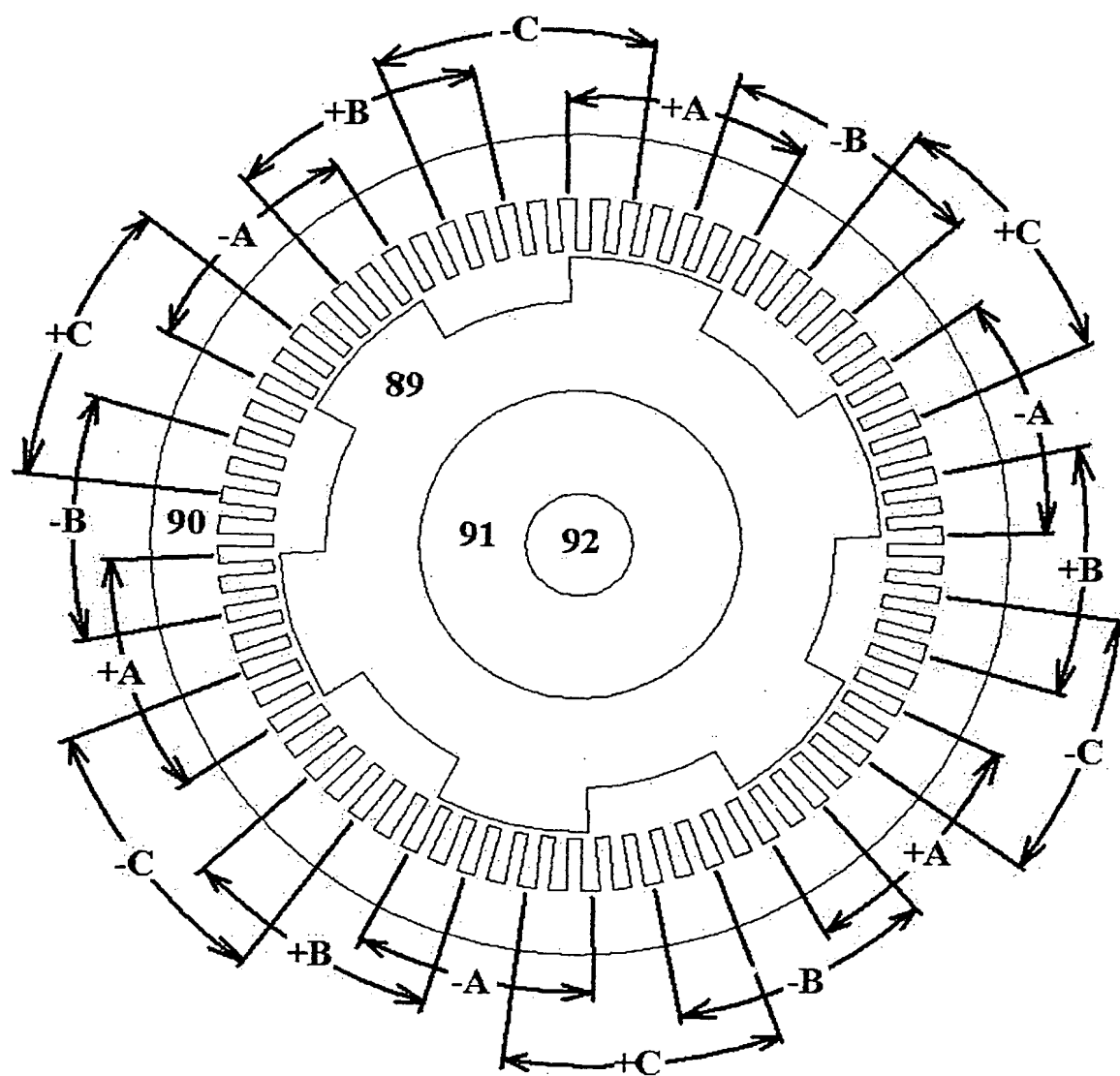


Fig.22





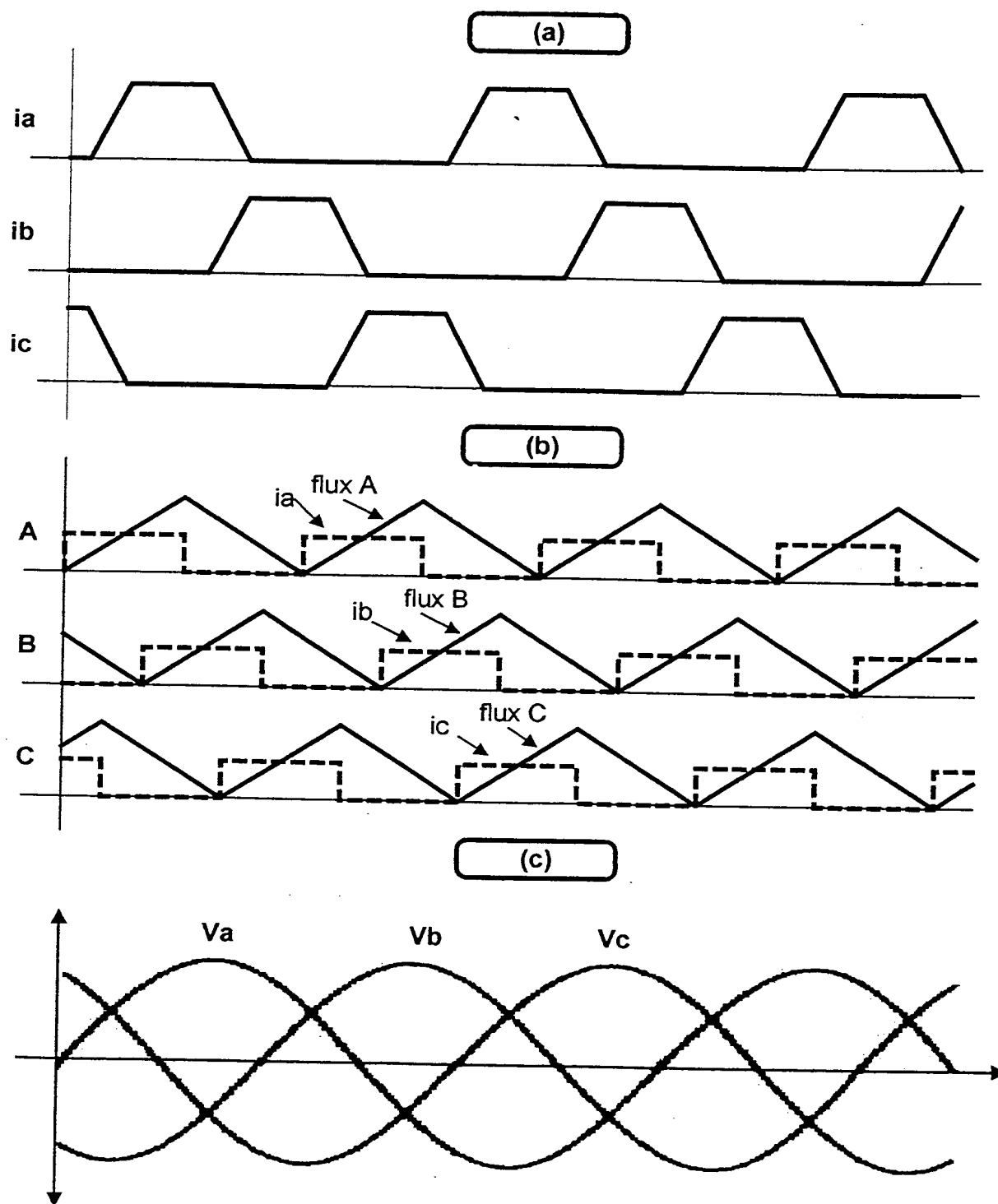


Fig.23

